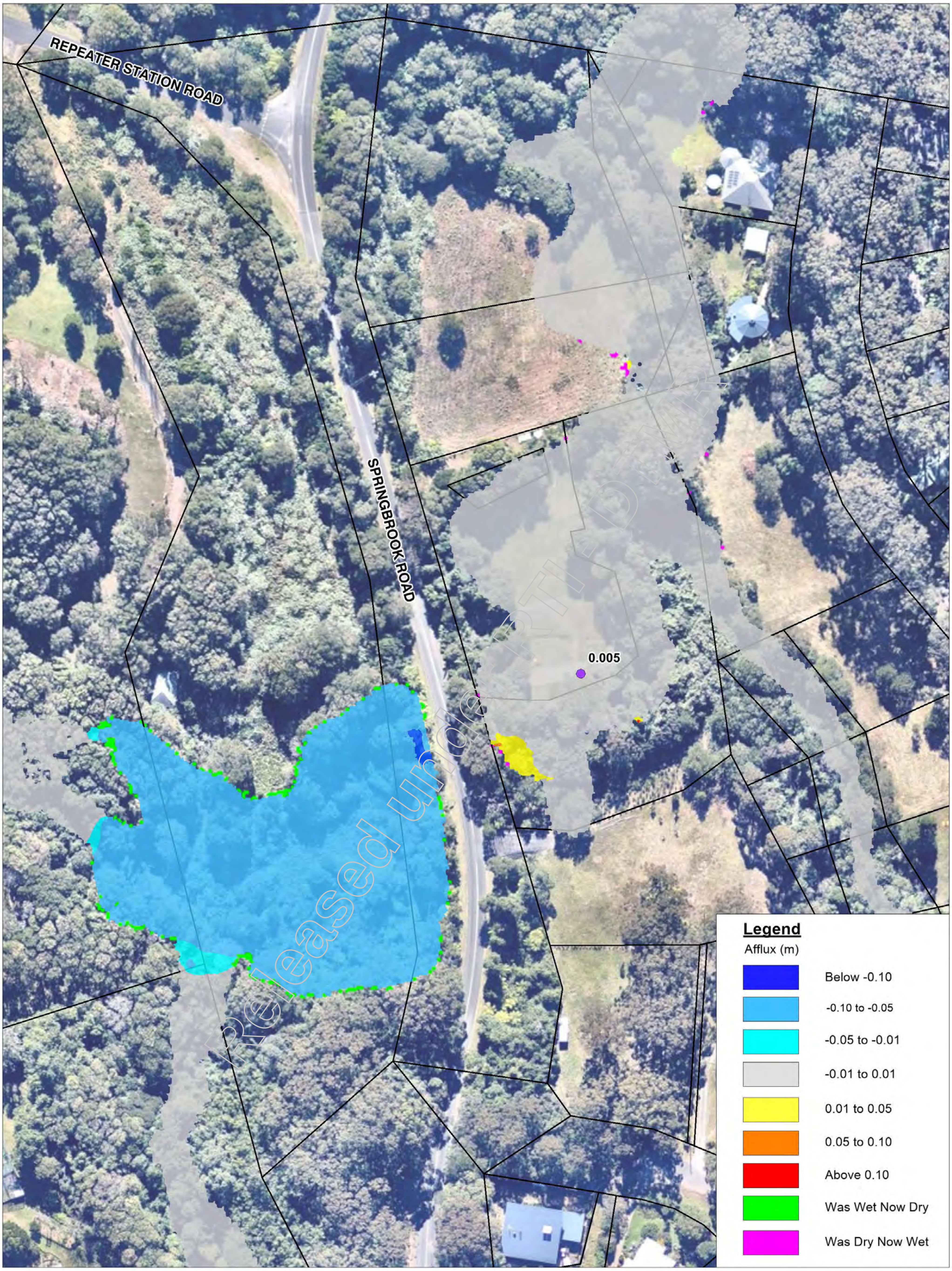

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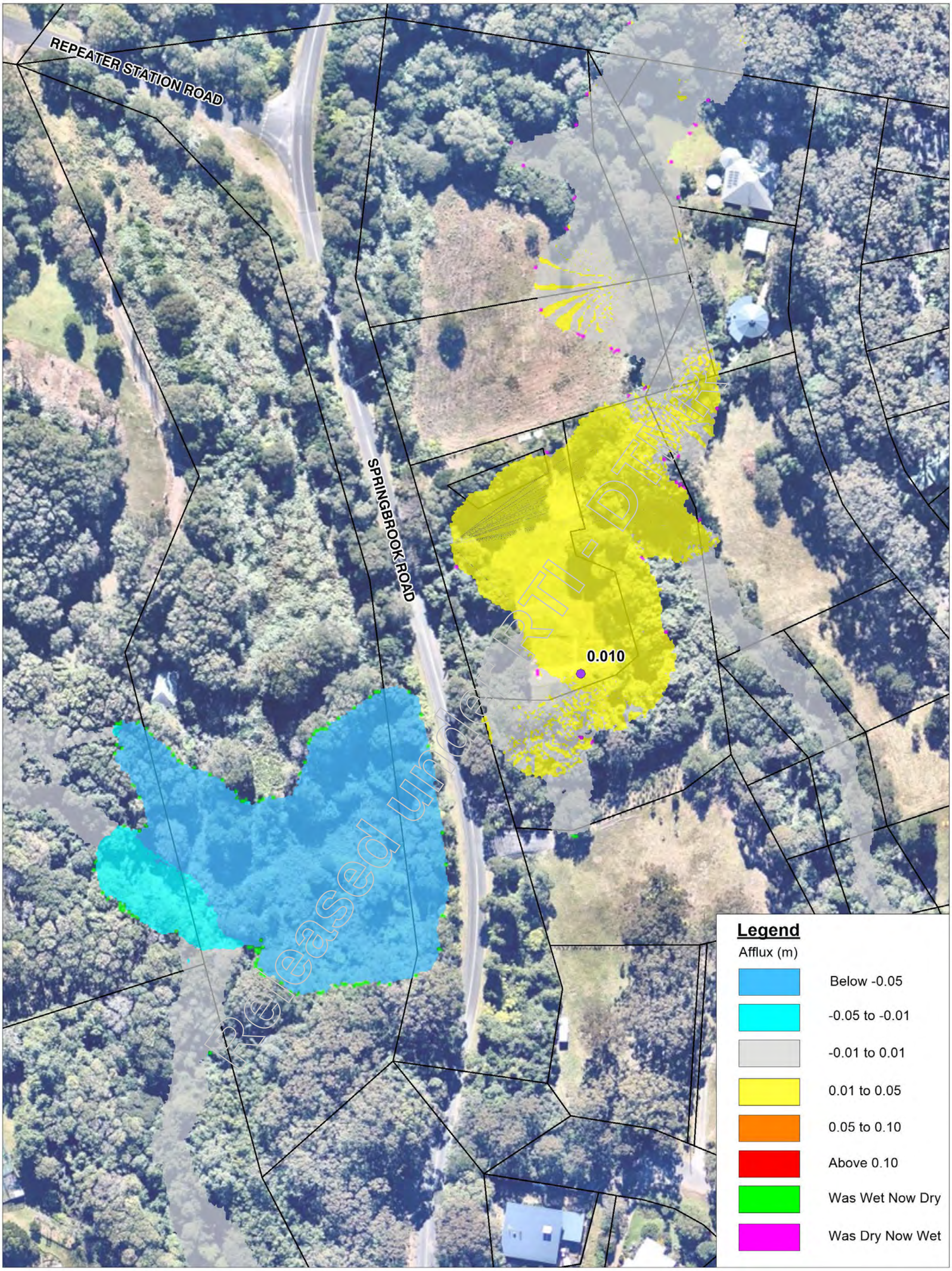
PAGE SIZE A3	DRAWING NO. 01_LilNerang_Afflux_D04_D04e_1%_001	REVISION A	Queensland Government Department of Main Roads	SMEC
	CREATED BY not relevant DATE 27/09/2018			SMEC Australia Ltd Level 1, 154 Melbourne Street South Brisbane QLD 4101
SCALE 1:1,000	PROJECT NO. 30032217 PROJECT TITLE LITTLE NERANG CREEK CULVERT REMEDIATION			
	TITLE **FLOOD AFFLUX MAP - 1% AEP D04 (4/1200mm RCP) vs. D04e (4/1280mm CSP)**			



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DRAWING NO. 02_LilNerang_Afflux_D04_D04e_2%_001

CREATED BY not relevant

DATE 27/09/2018

STATUS ISSUE

REVISION A

PROJECT NO. 30032217

PROJECT TITLE LITTLE NERANG CREEK CULVERT REMEDIATION

TITLE **FLOOD AFFLUX MAP - 2% AEP D04 (4/1200mm RCP) vs. D04e (4/1280mm CSP)**

CLIENT

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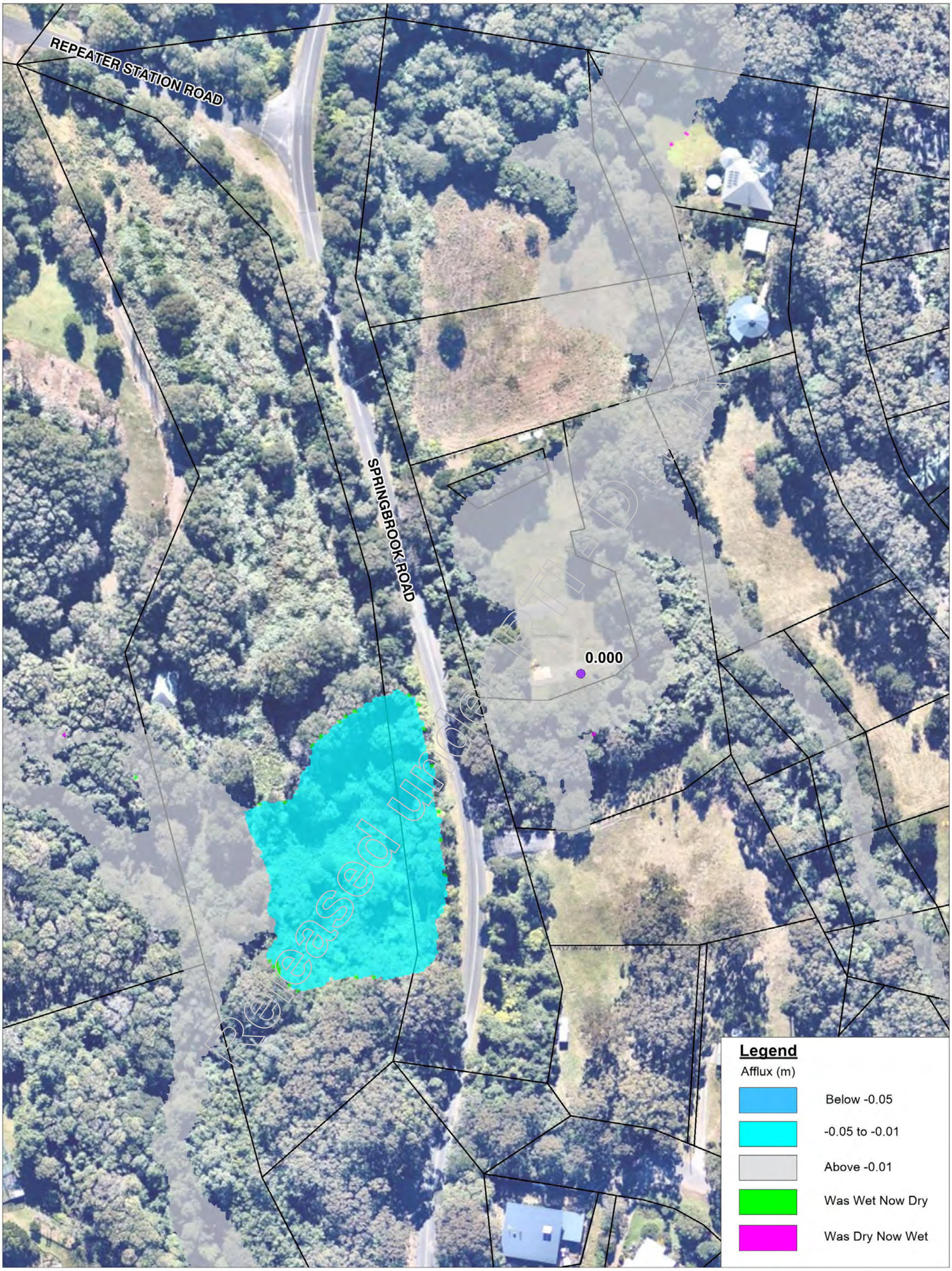

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DRAWING NO. 03_LilNerang_Afflux_D04_D04e_5%_001

CREATED BY not relevant

DATE 27/09/2018

STATUS ISSUE

REVISION A

PROJECT NO. 30032217

PROJECT TITLE LITTLE NERANG CREEK CULVERT REMEDIATION

TITLE **FLOOD AFFLUX MAP - 5% AEP D04 (4/1200mm RCP) vs. D04e (4/1280mm CSP)**

CLIENT

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CONSULTANT

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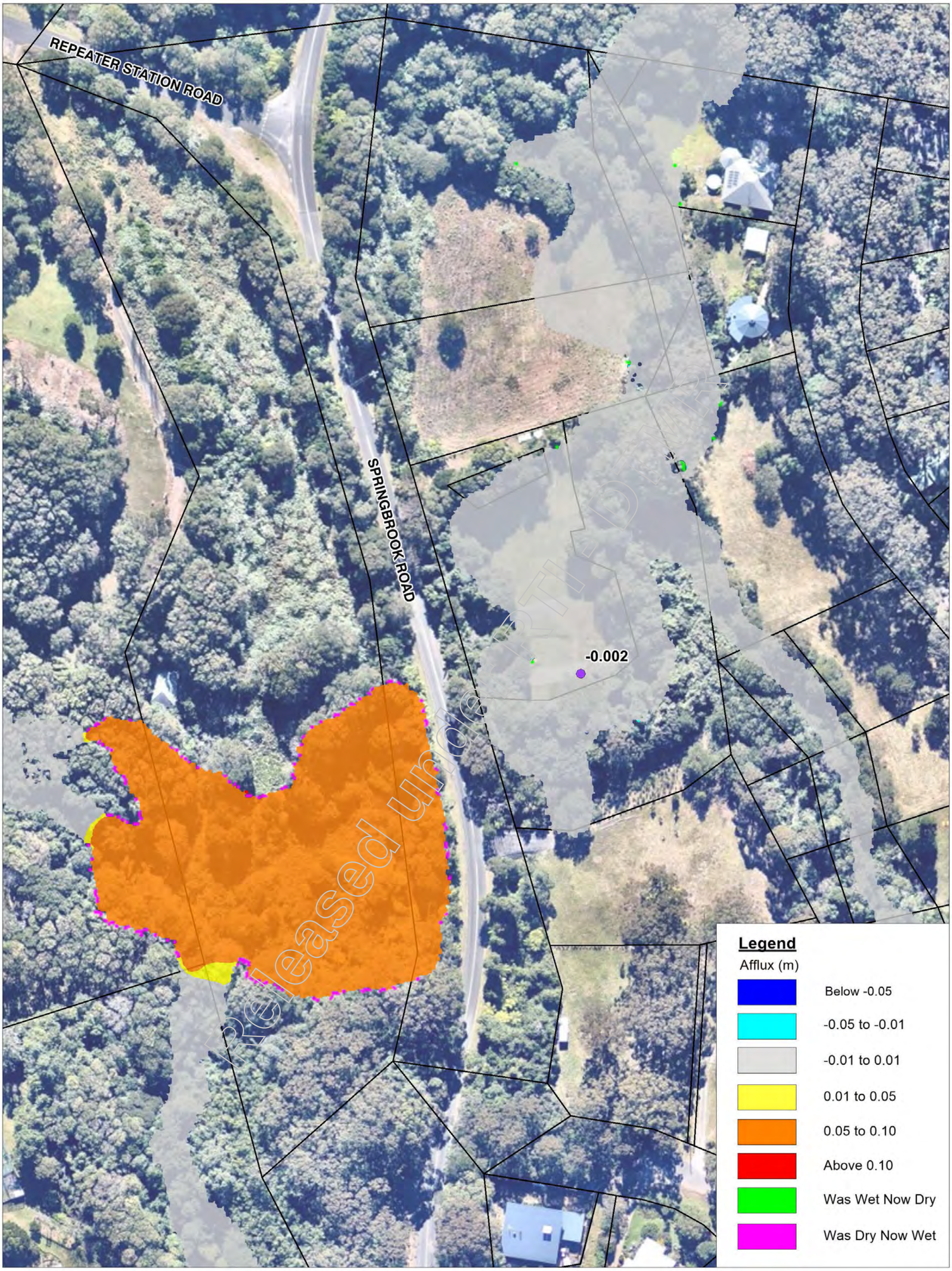

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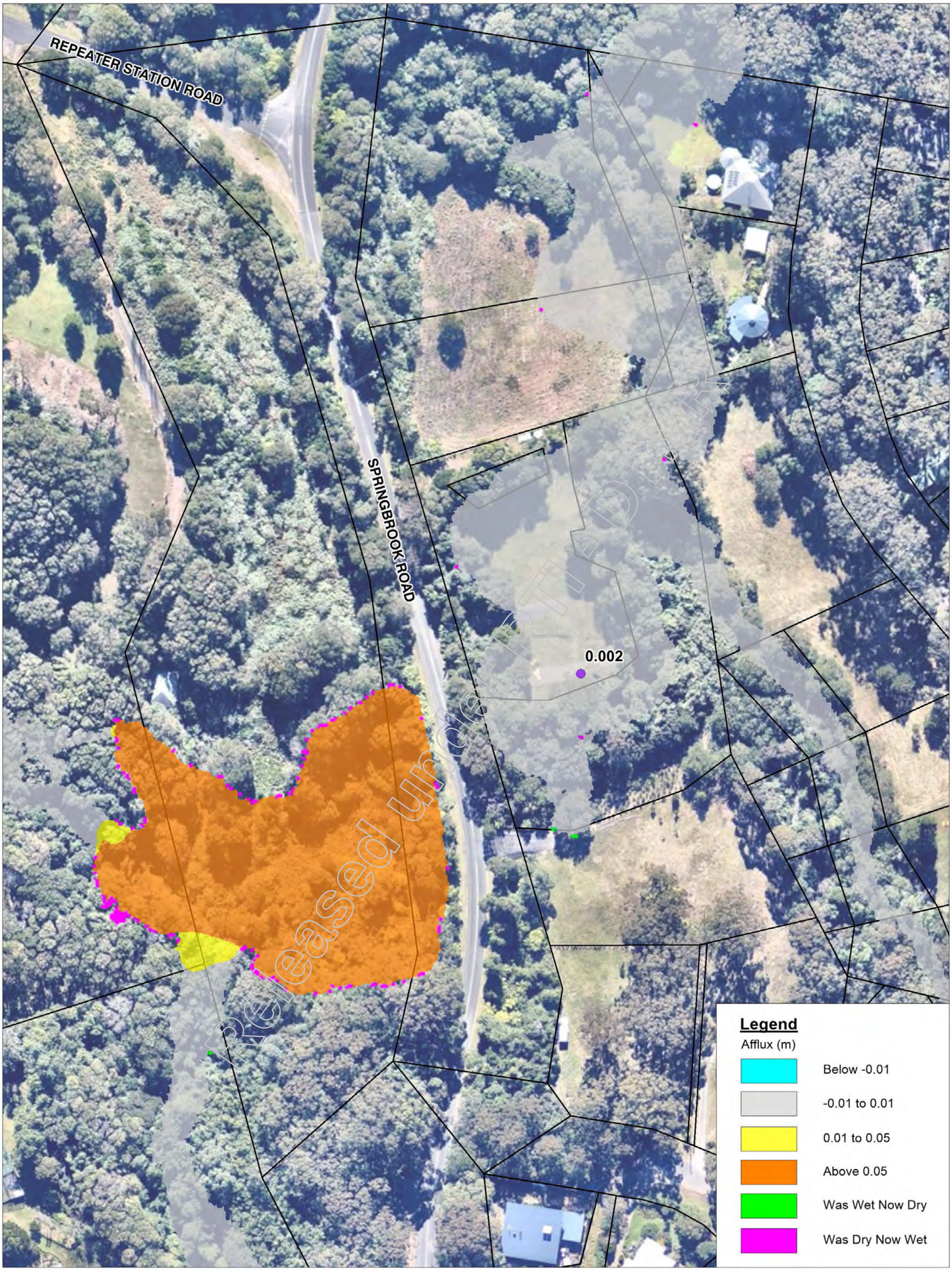
	PROJECT NO. 30032217 PROJECT TITLE LITTLE NERANG CREEK CULVERT REMEDIATION	CONSULTANT SMEC SMEC Australia Ltd Level 1, 154 Melbourne Street South Brisbane QLD 4101
	TITLE FLOOD AFFLUX MAP - 1% AEP D04c (3/1350mm RCP) vs. D04e (4/1280mm CSP)	



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DRAWING NO. 05_LilNerang_Afflux_D04c_D04e_2%_001

CREATED BY not relevant

DATE 27/09/2018

STATUS ISSUE

REVISION A

PROJECT NO. 30032217

PROJECT TITLE LITTLE NERANG CREEK CULVERT REMEDIATION

TITLE **FLOOD AFFLUX MAP - 2% AEP D04c (3/1350mm RCP) vs. D04e (4/1280mm CSP)**

CLIENT Queensland Government Department of Main Roads

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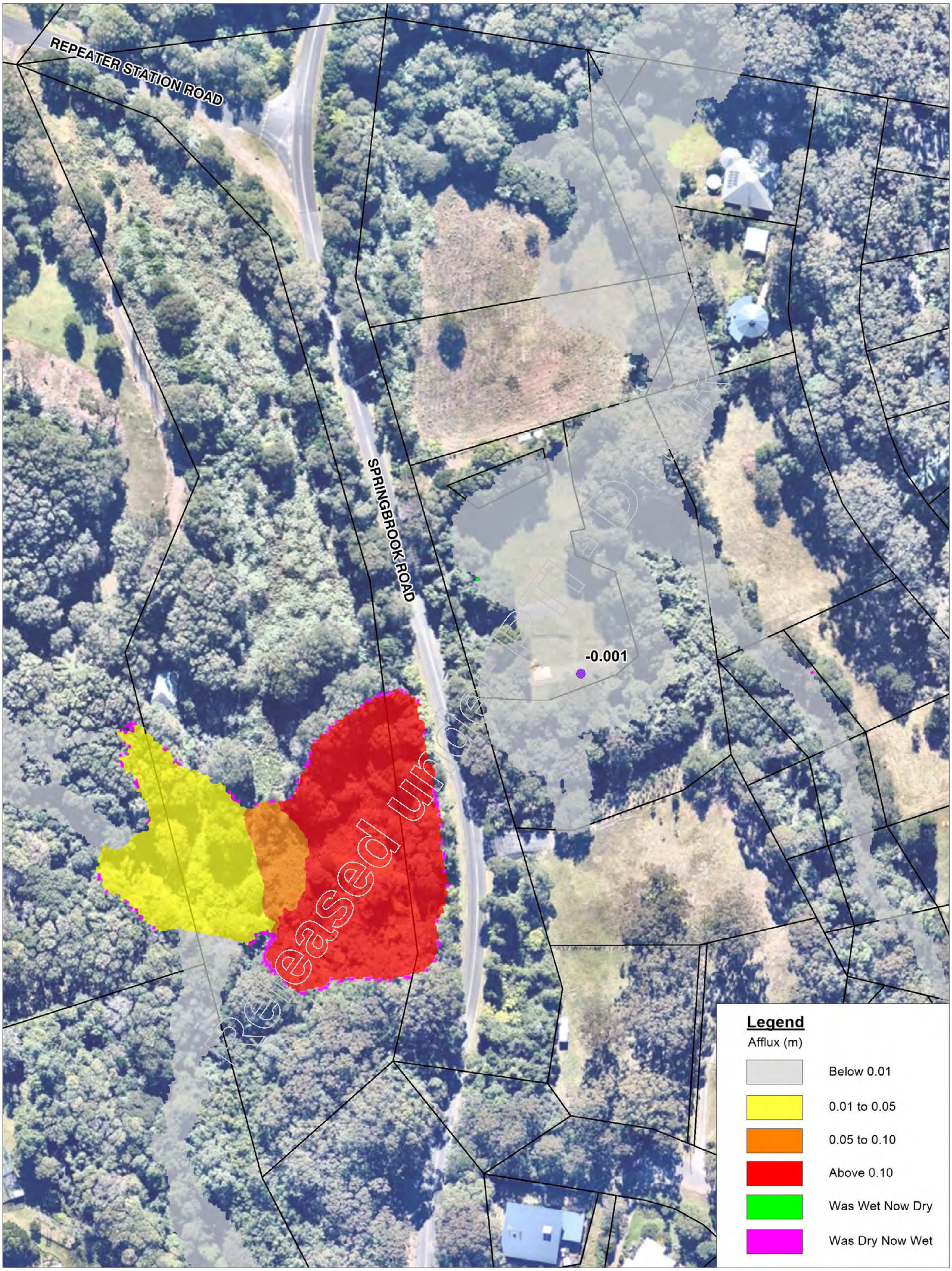

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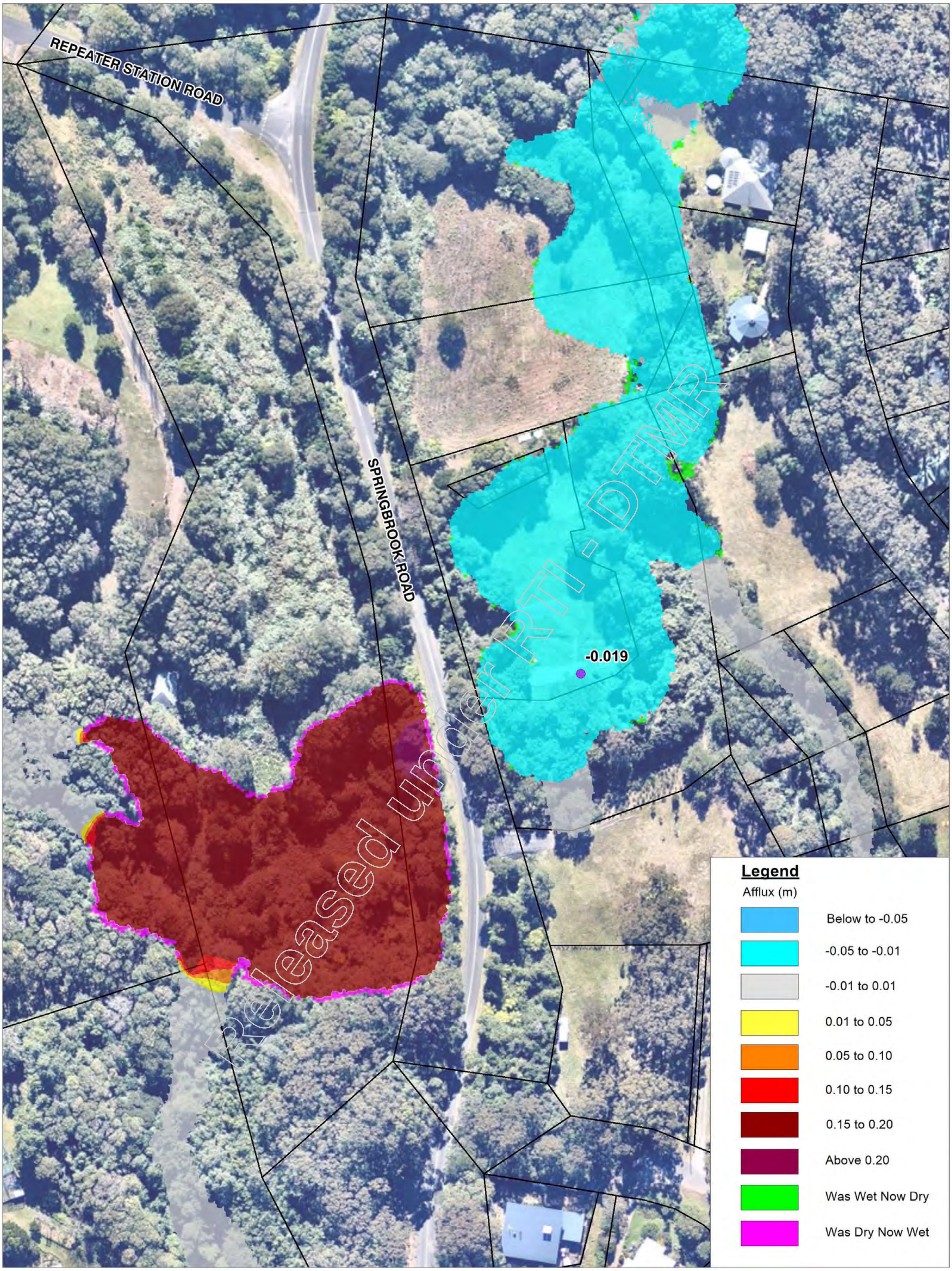

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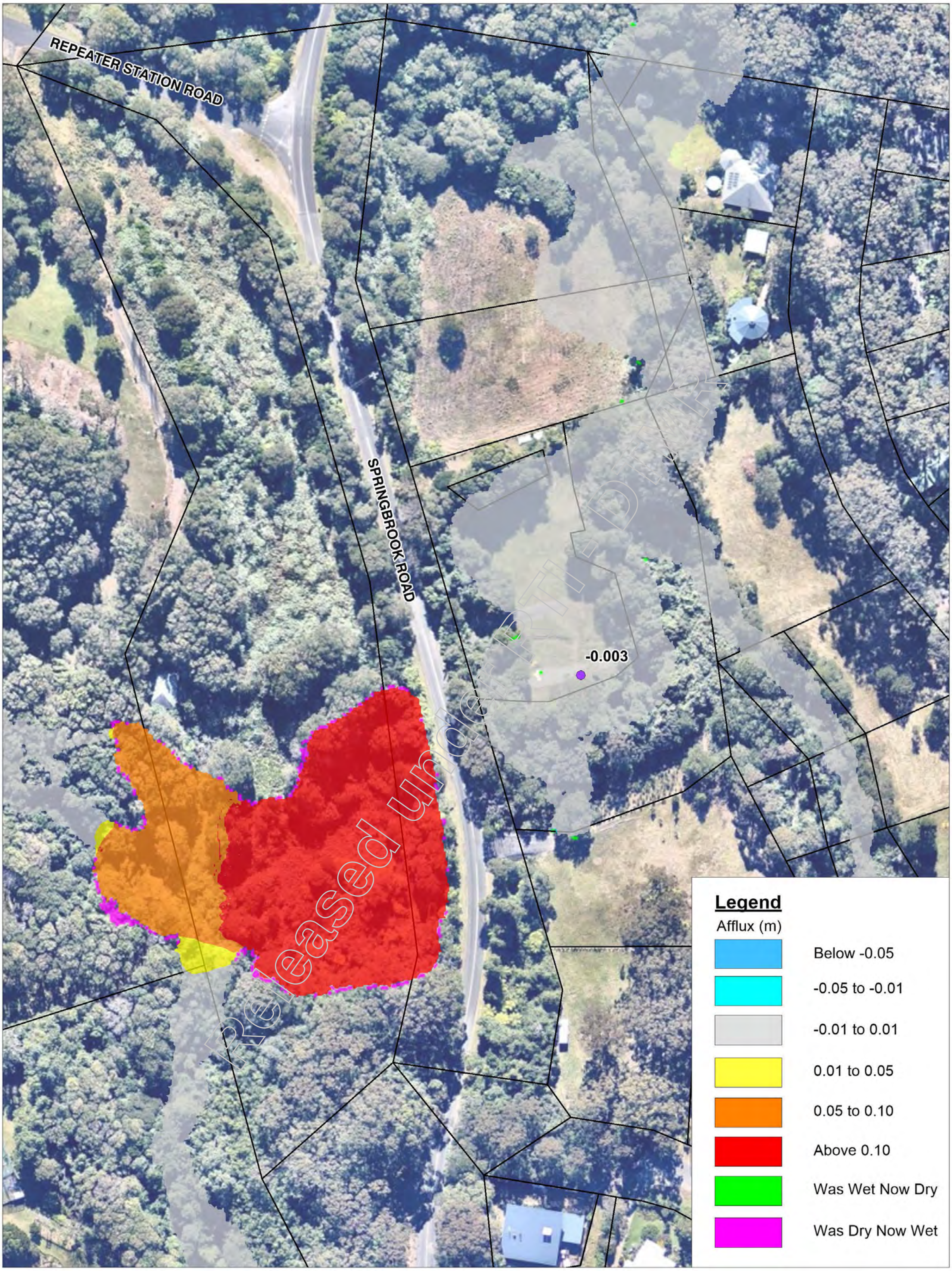
	PROJECT NO. 30032217	PROJECT TITLE LITTLE NERANG CREEK CULVERT REMEDIATION		
	TITLE **FLOOD AFFLUX MAP - 1% AEP D04f (4/1200mm RCP with 20% Blockage) vs. D04e (4/1280mm CSP)**			



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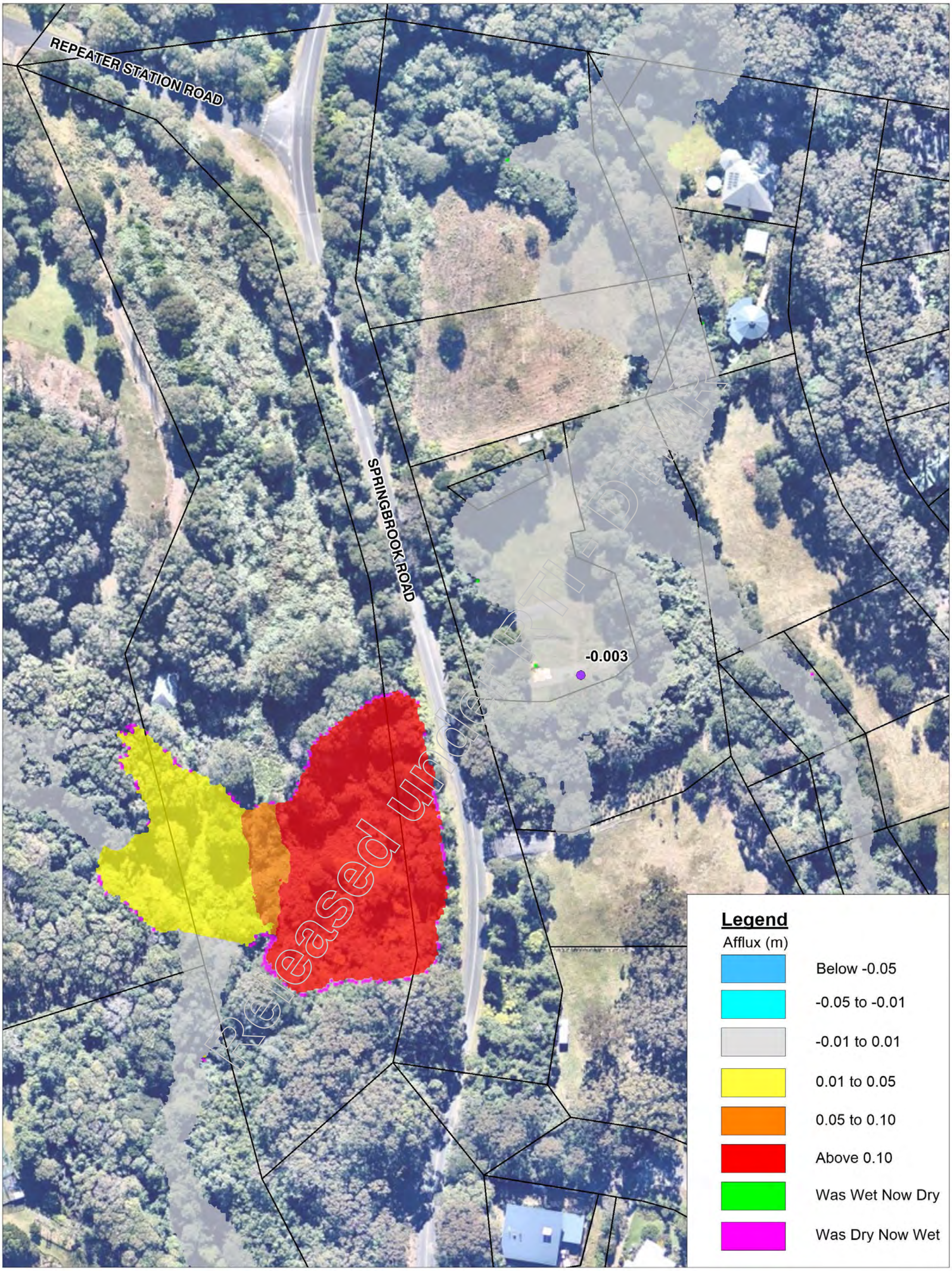

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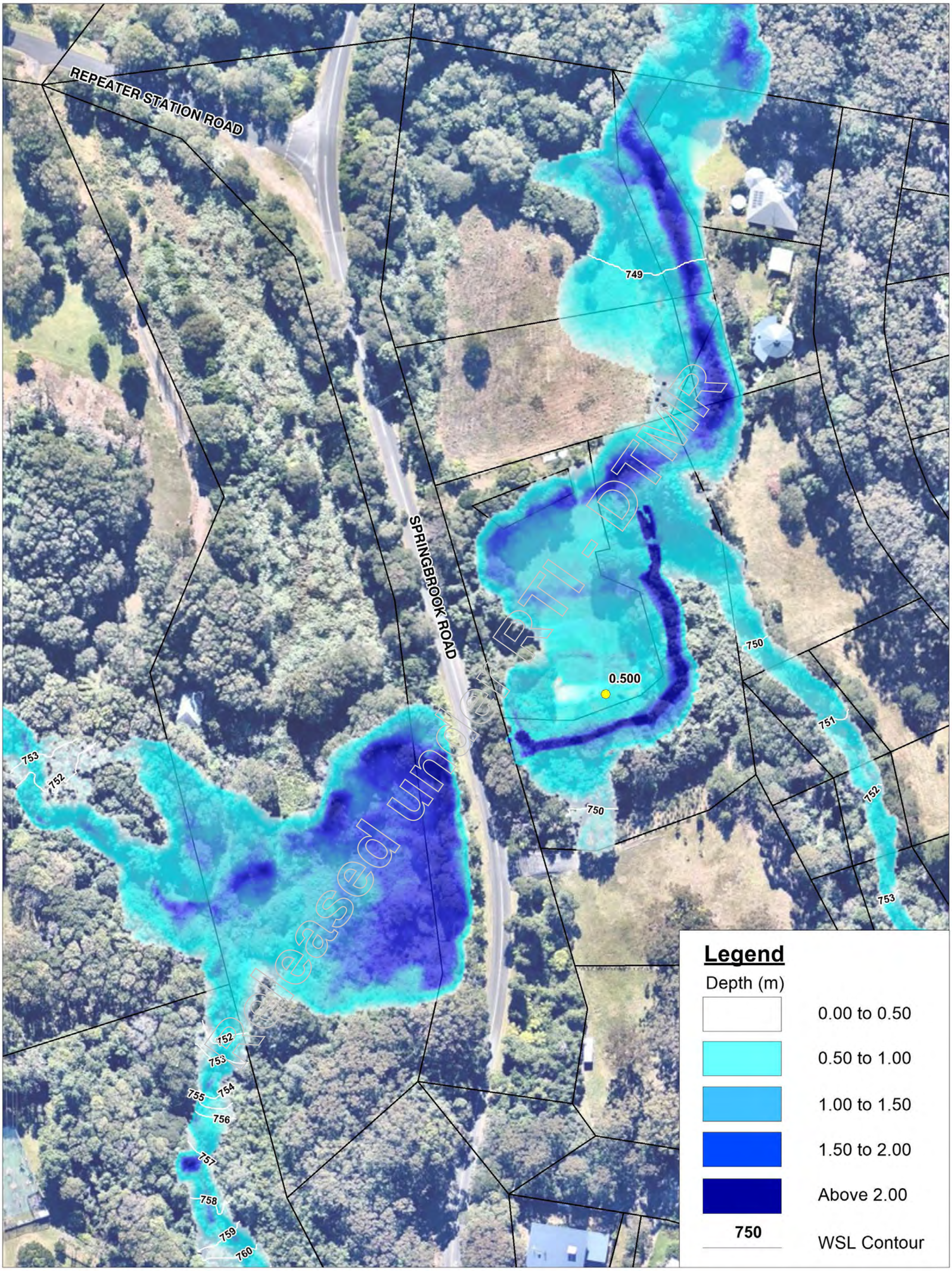

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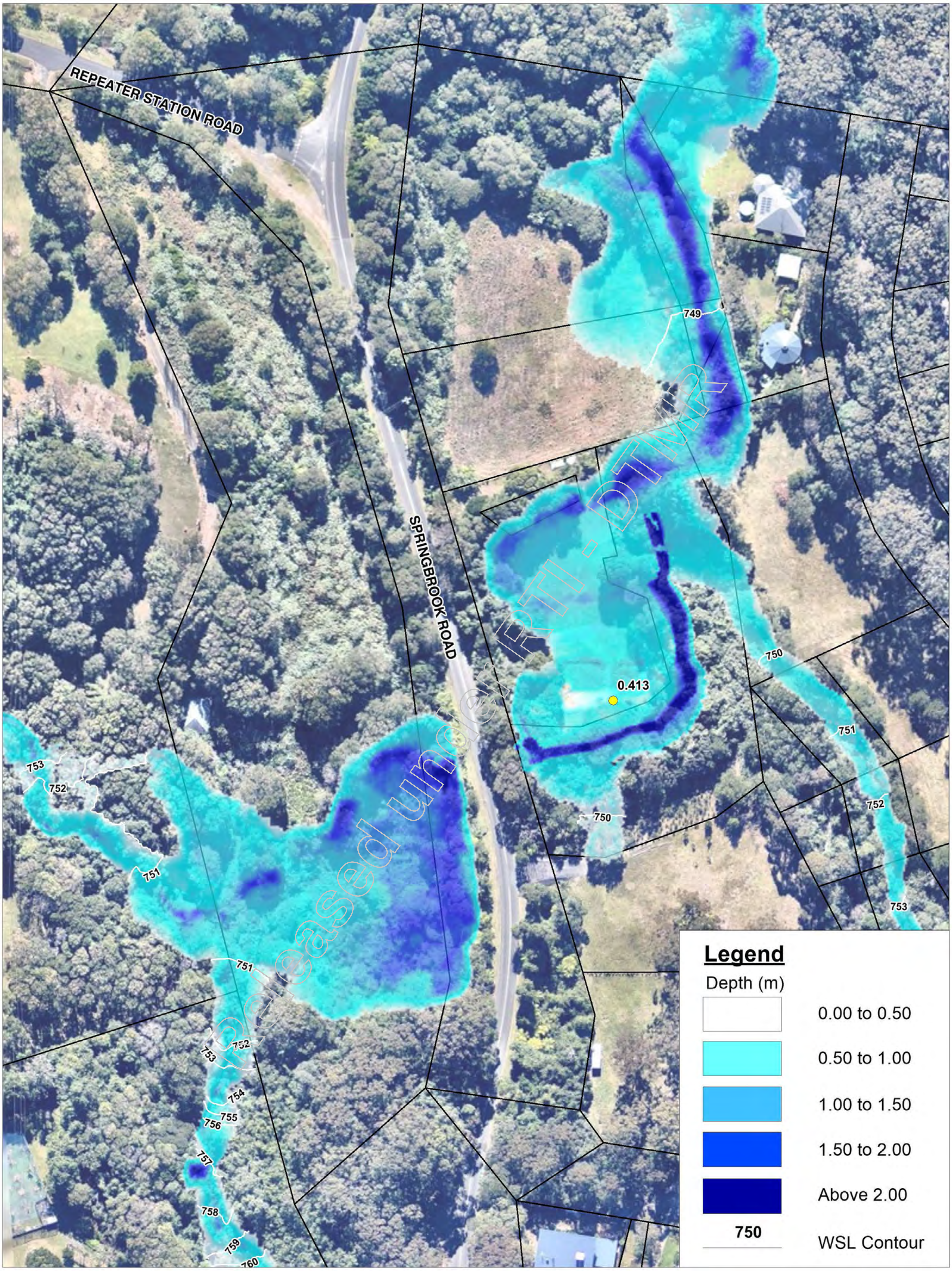
	TITLE **FLOOD DEPTH MAP - 1% AEP D04e (4/1280mm CSP)**		SMEC Australia Ltd Level 1, 154 Melbourne Street South Brisbane QLD 4101



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DRAWING NO. 02_LilNerang_Depth_D04e_2%_001

CREATED BY not relevant

DATE 26/09/2018

STATUS ISSUE

REVISION A

PROJECT NO. 30032217

PROJECT TITLE LITTLE NERANG CREEK CULVERT REMEDIATION

TITLE **FLOOD DEPTH MAP - 2% AEP D04e (4/1280mm CSP)**

CLIENT

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CONSULTANT

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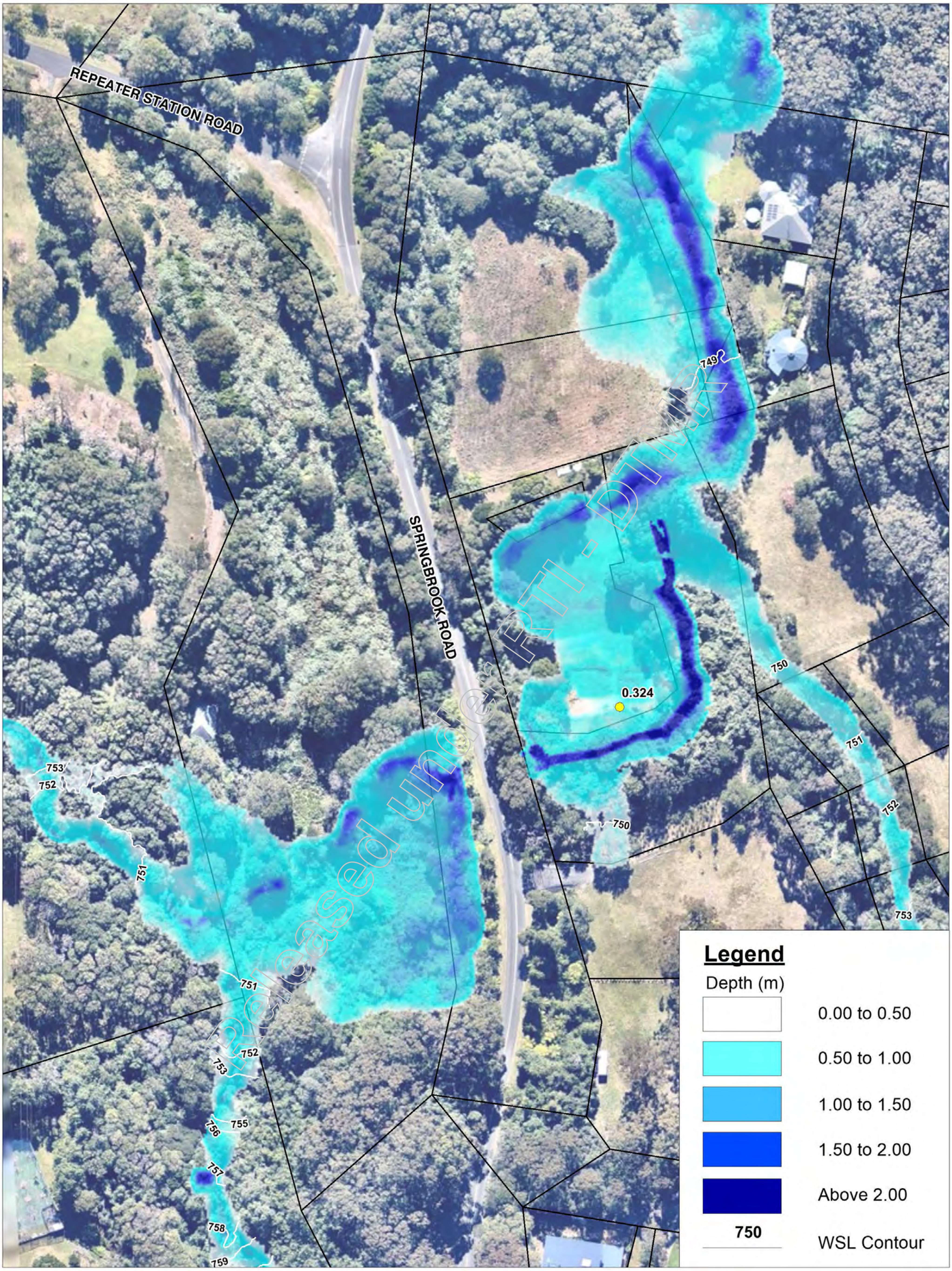

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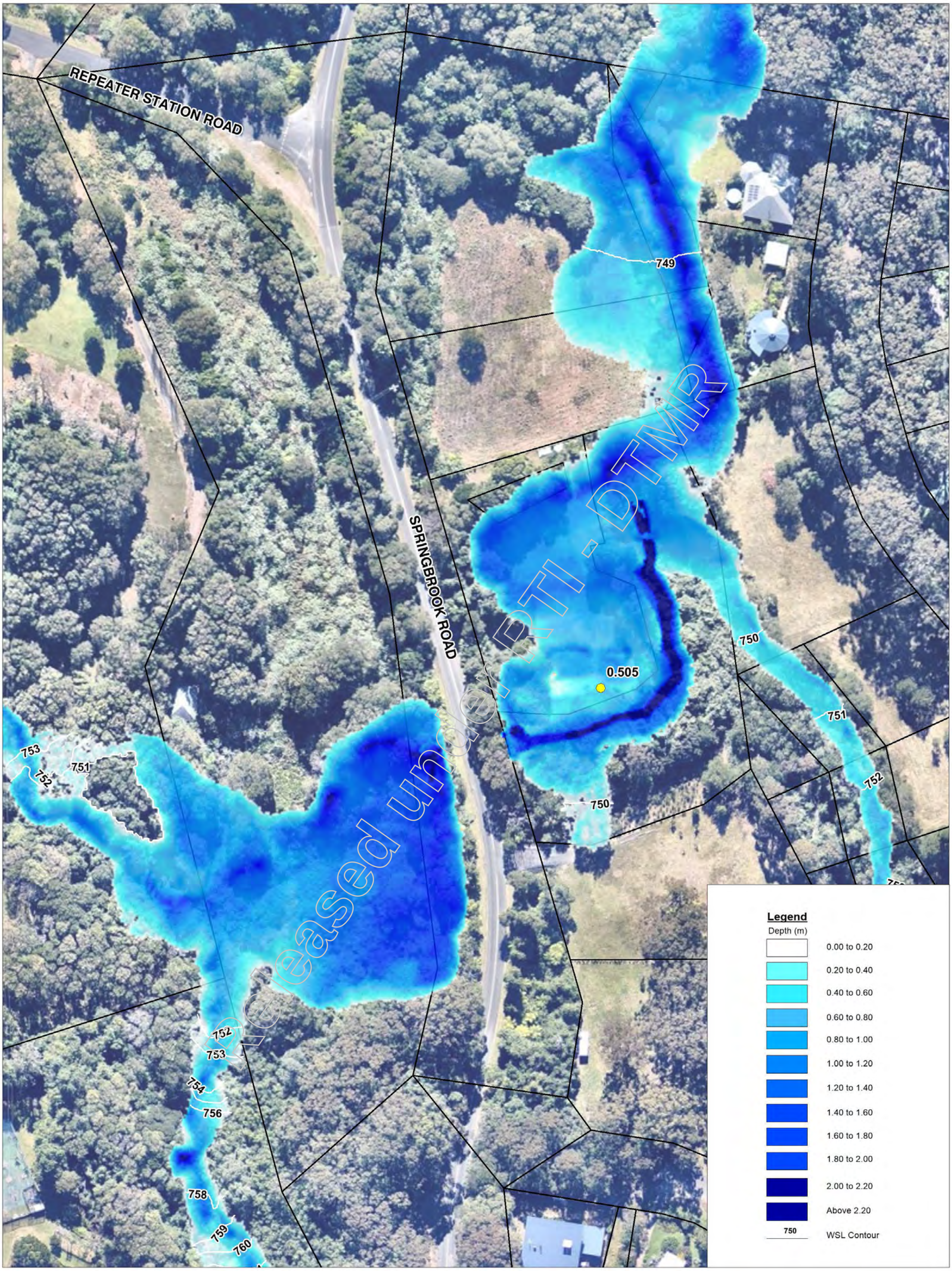

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STATUS ISSUE

DRAWING NO. 04_LilNerang_Depth_D04_1%_001

REVISION A

CREATED BY not relevant

DATE 28/09/2018

PROJECT NO. 30032217

PROJECT TITLE LITTLE NERANG CREEK CULVERT REMEDIATION

TITLE **FLOOD DEPTH MAP - 1% AEP D04 (4/1200mm RCP)**

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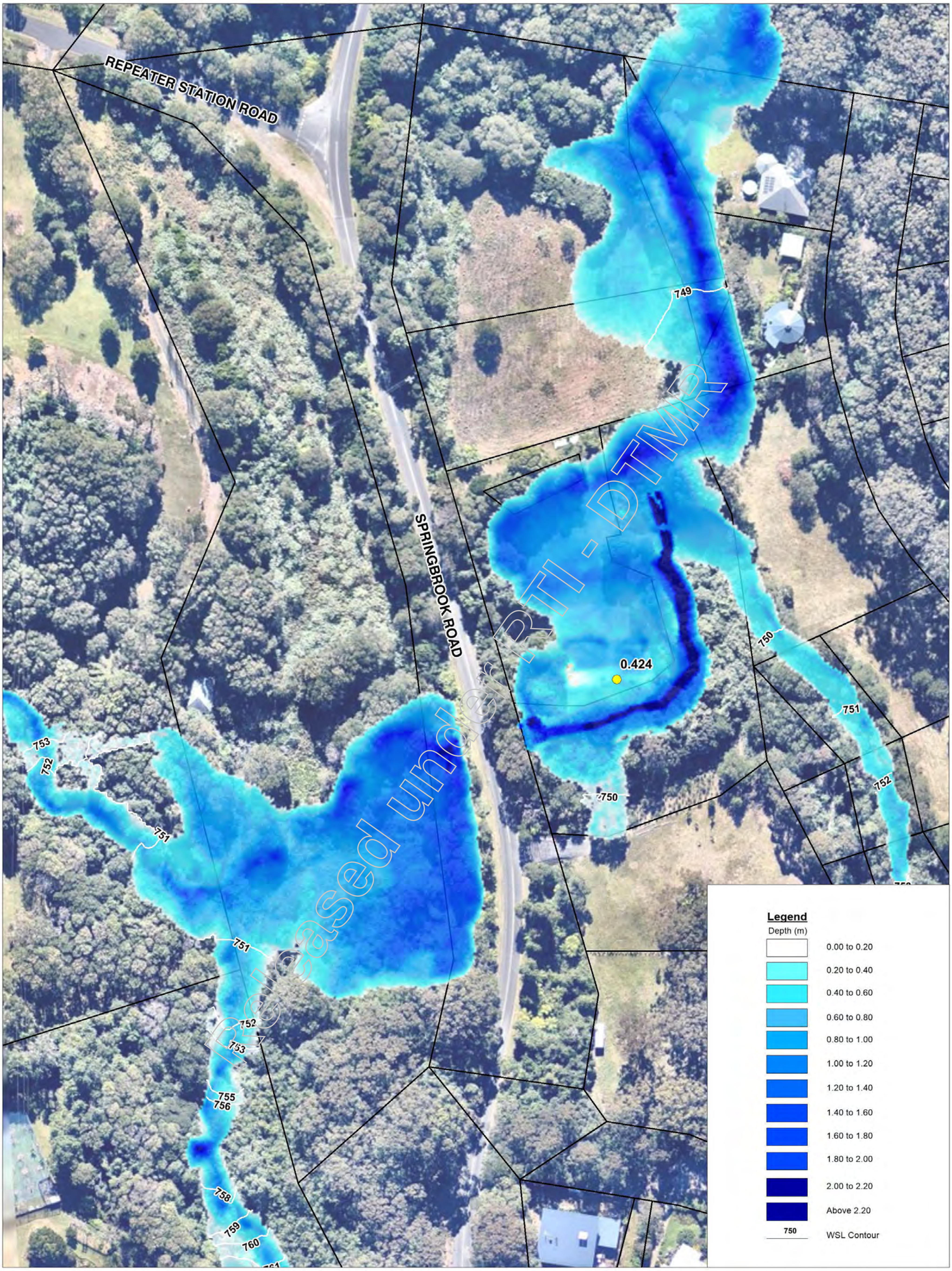

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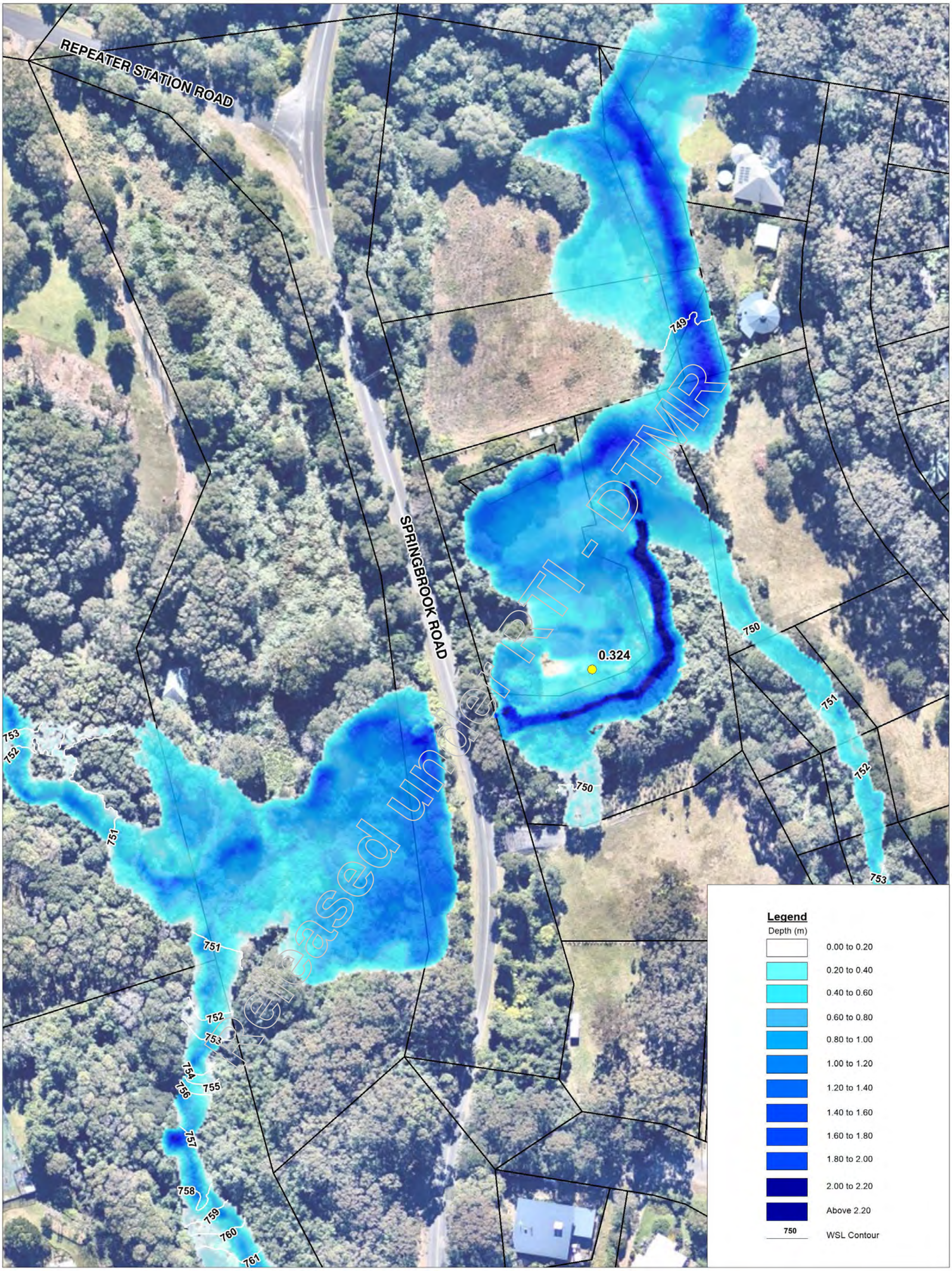
	TITLE **FLOOD DEPTH MAP - 2% AEP D04 (4/1200mm RCP)**		SMEC Australia Ltd, Level 1, 154 Melbourne Street, South Brisbane QLD 4101



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	CREATED BY not relevant DATE 04/09/2018			SMEC Australia Ltd Level 1, 154 Melbourne Street South Brisbane QLD 4101
SCALE 1:1,000	PROJECT NO. 30032217 PROJECT TITLE LITTLE NERANG CREEK CULVERT REMEDIATION			
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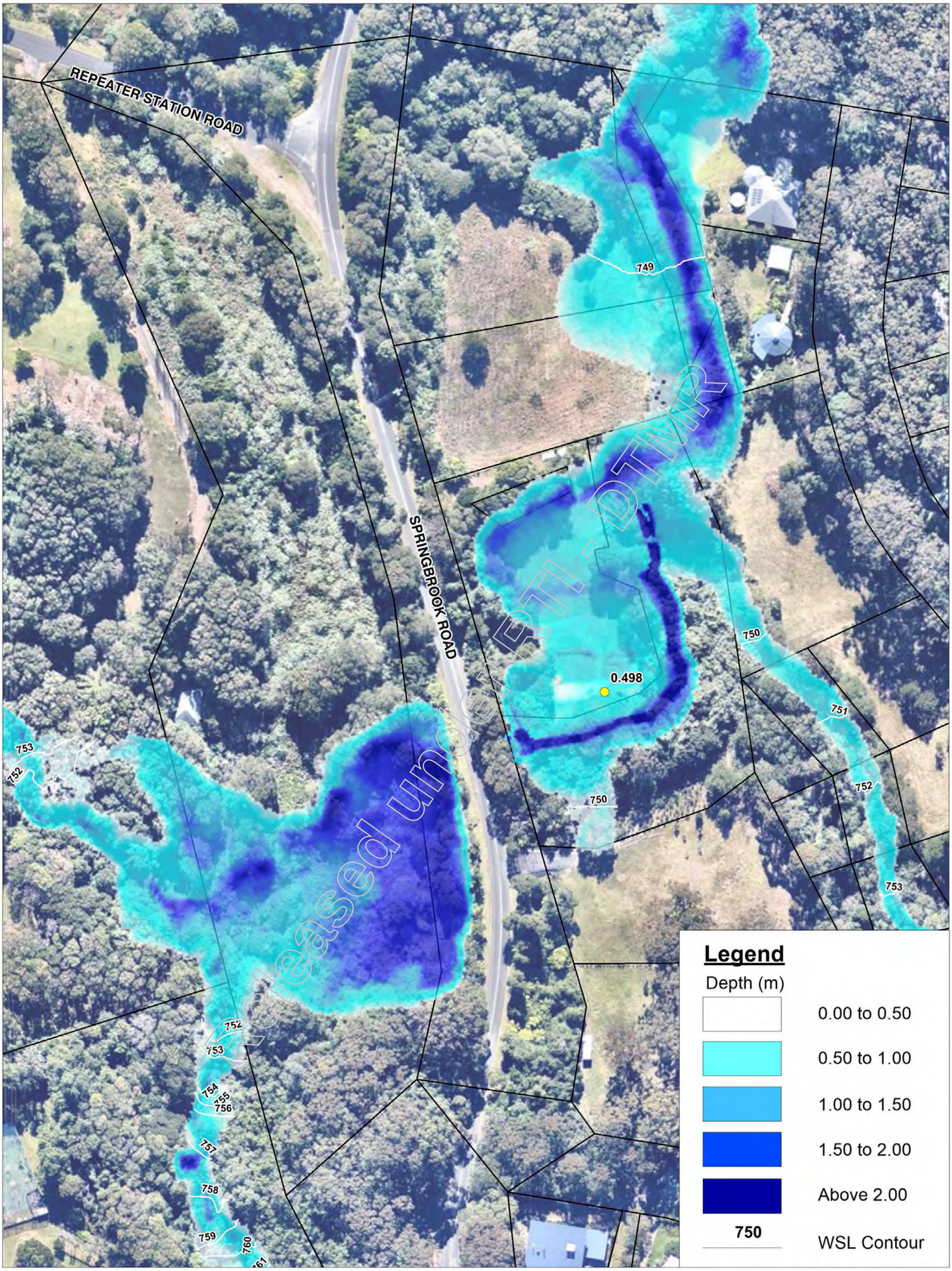

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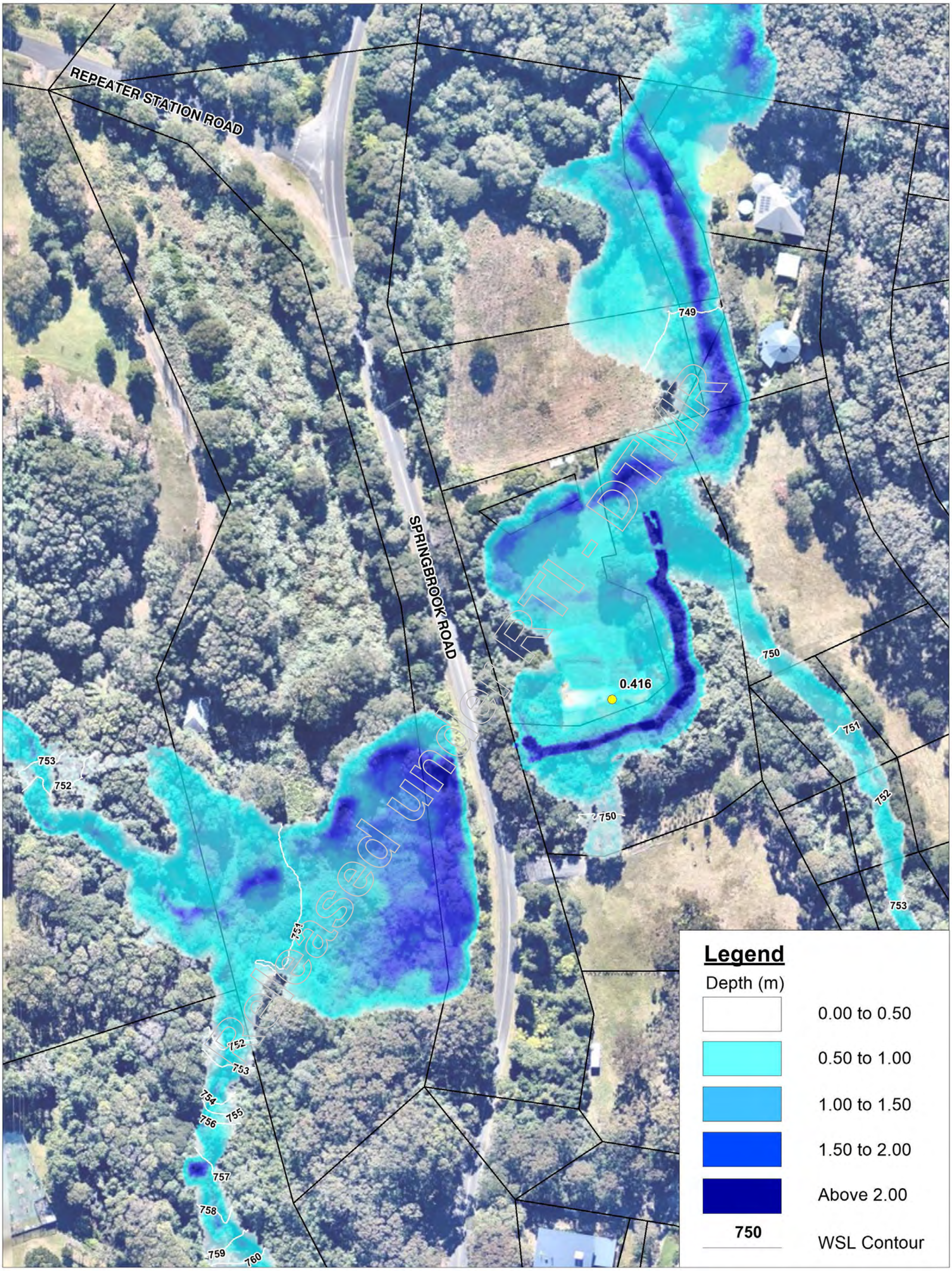

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DRAWING NO. 08_LilNerang_Depth_D04c_2%_001

CREATED BY not relevant

DATE 28/09/2018

STATUS ISSUE

REVISION A

PROJECT NO. 30032217

PROJECT TITLE LITTLE NERANG CREEK CULVERT REMEDIATION

TITLE **FLOOD DEPTH MAP - 2% AEP D04c (3/1350mm RCP)**

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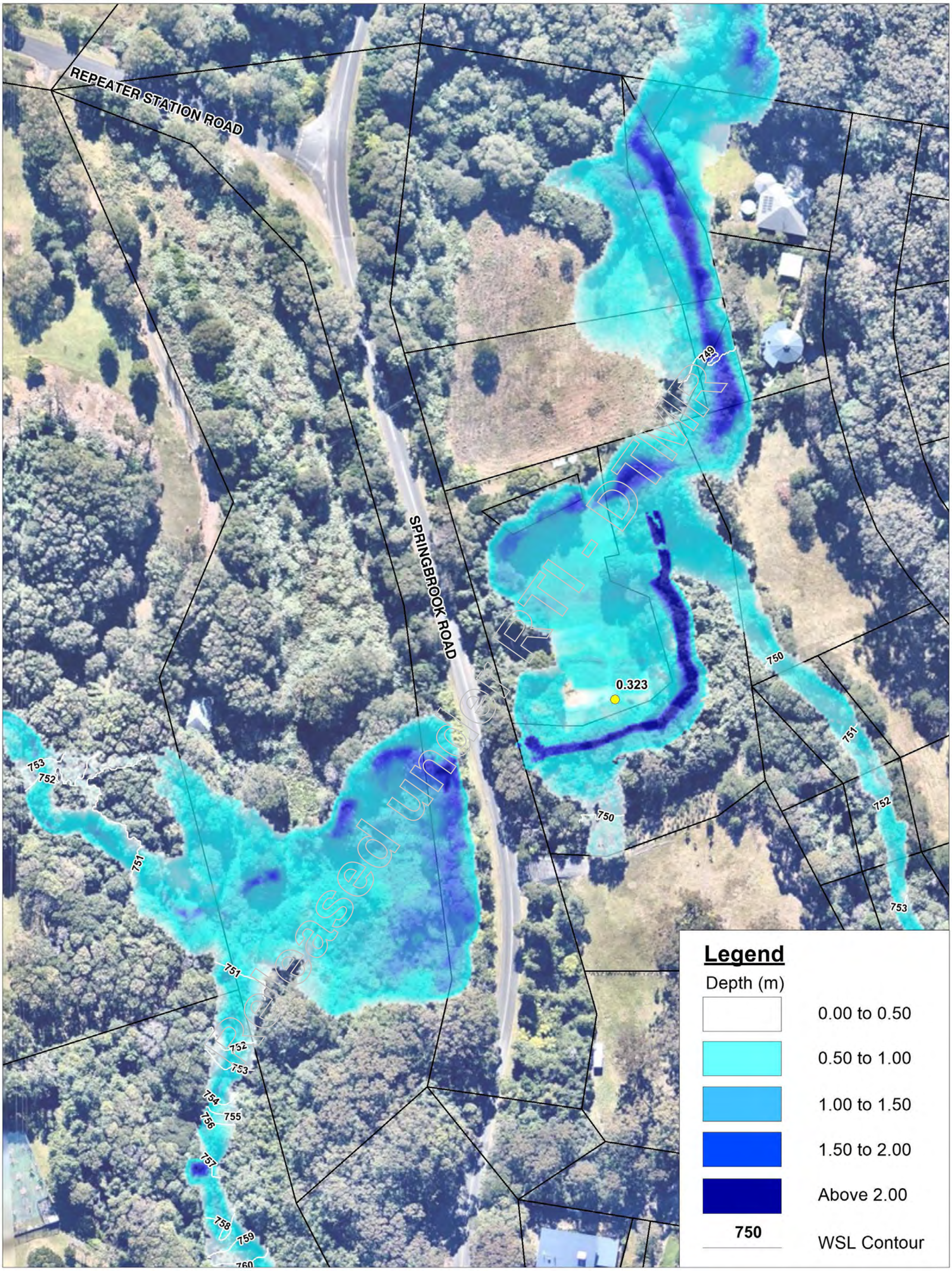

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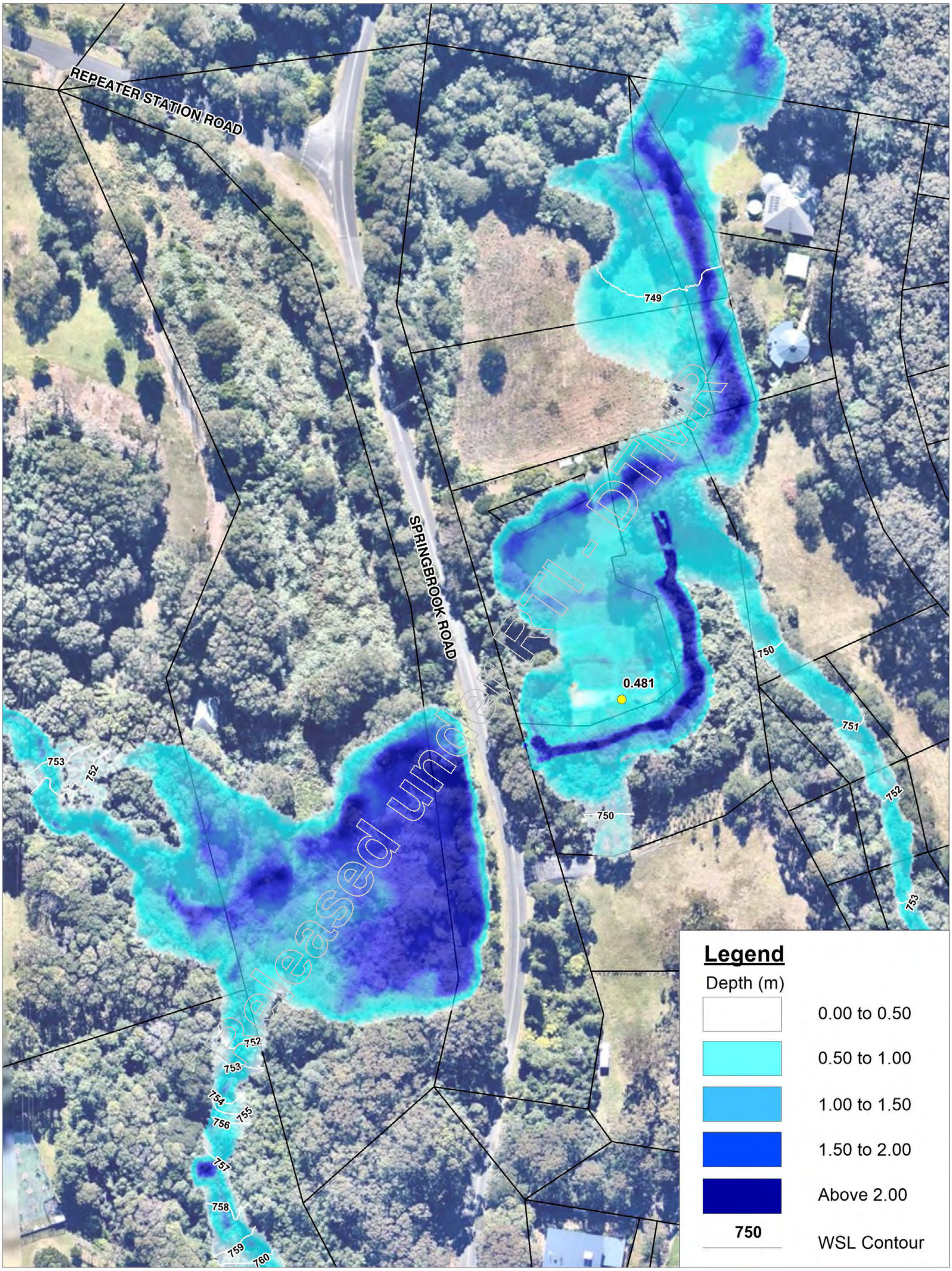
	PROJECT NO. 30032217 PROJECT TITLE LITTLE NERANG CREEK CULVERT REMEDIATION		CONSULTANT SMEC SMEC Australia Ltd Level 1, 154 Melbourne Street South Brisbane QLD 4101
	TITLE **FLOOD DEPTH MAP - 5% AEP D04c (3/1350mm RCP)**		



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DATE 28/09/2018
STATUS ISSUE
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PROJECT NO. 30032217
PROJECT TITLE LITTLE NERANG CREEK CULVERT REMEDIATION
TITLE **FLOOD DEPTH MAP - 1% AEP D04f (4/1200mm RCP with 20% Blockage)**

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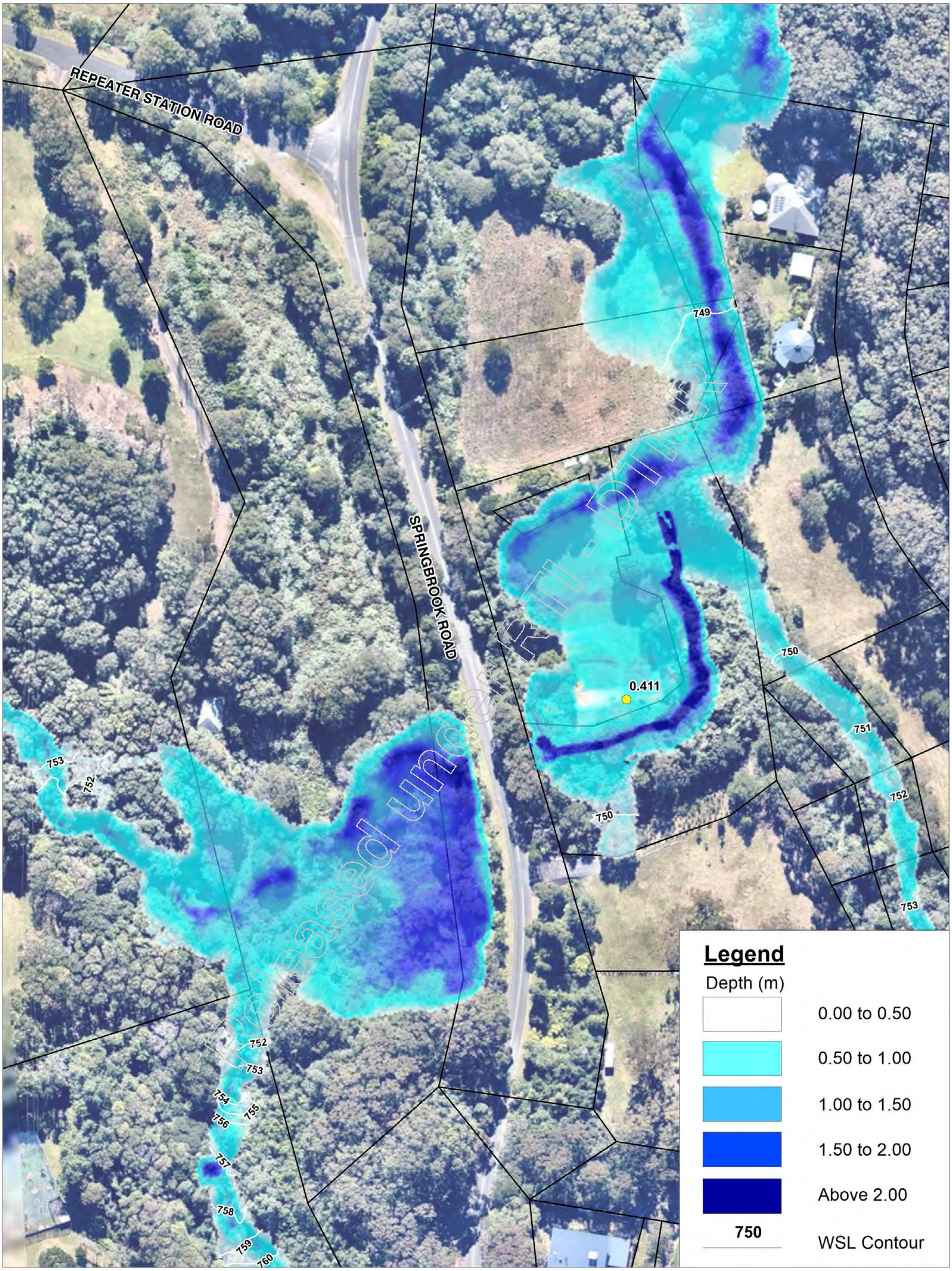

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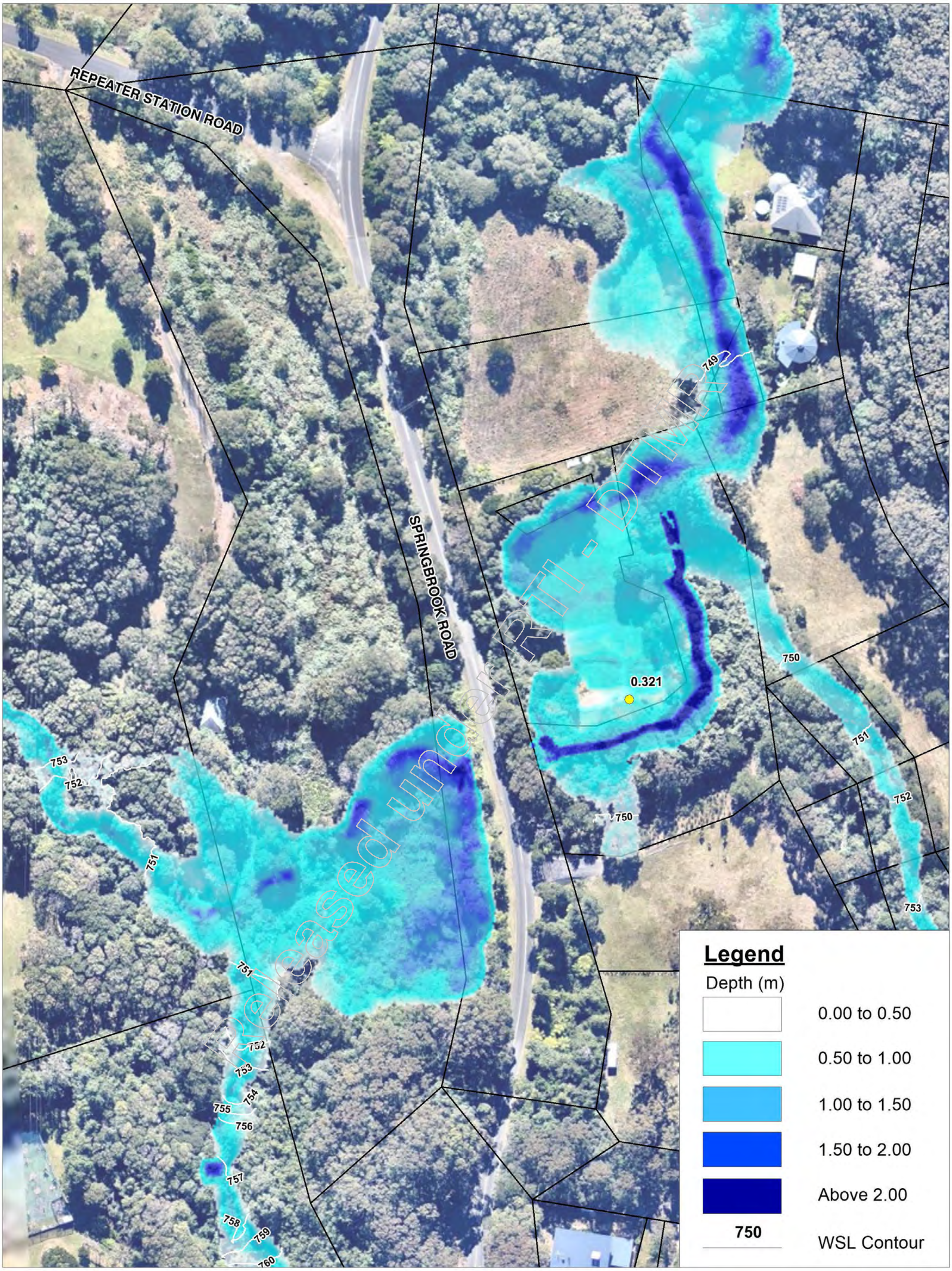
	PROJECT NO. 30032217 PROJECT TITLE LITTLE NERANG CREEK CULVERT REMEDIATION			
	TITLE **FLOOD DEPTH MAP - 2% AEP D04f (4/1200mm RCP with 20% Blockage)**			



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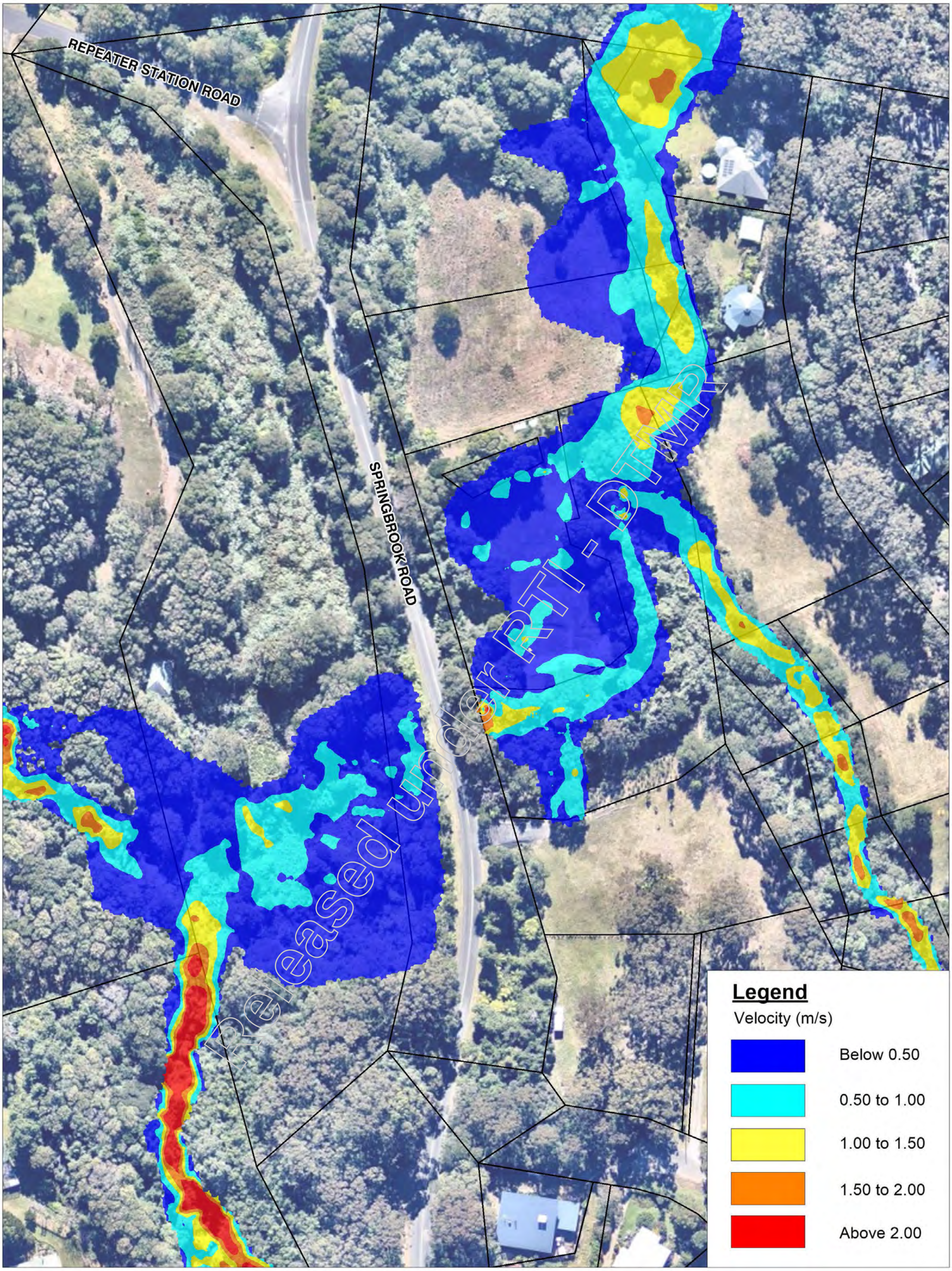

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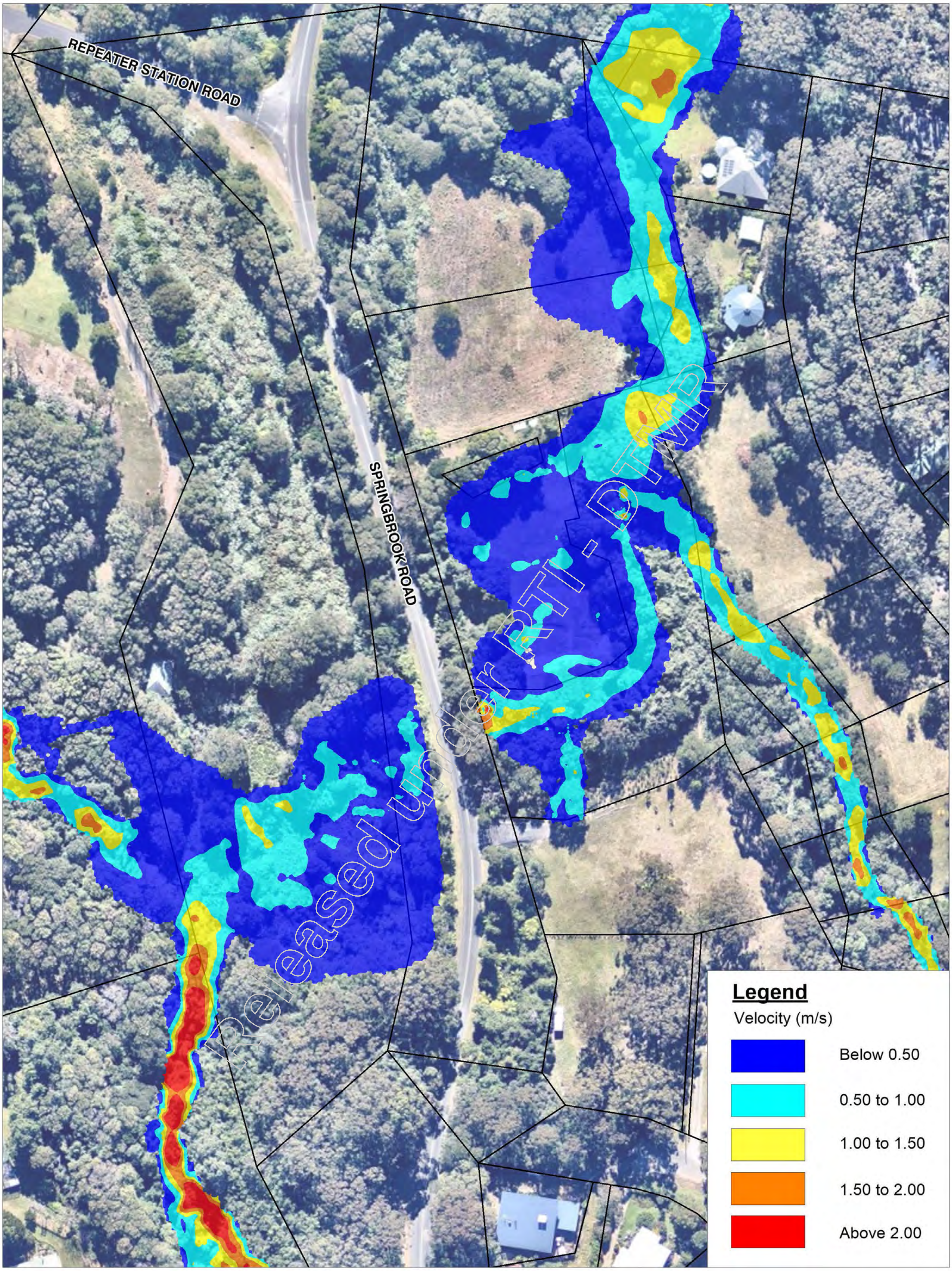
			CONSULTANT SMEC SMEC Australia Ltd Level 1, 154 Melbourne Street South Brisbane QLD 4101



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DRAWING NO. 02_LilNerang_Velocity_D04e_2%_001

CREATED BY not relevant

DATE 27/09/2018

STATUS ISSUE

REVISION A

PROJECT NO. 30032217

PROJECT TITLE LITTLE NERANG CREEK CULVERT REMEDIATION

TITLE **FLOOD VELOCITY MAP - 2% AEP D04e (4/1280mm CSP)**

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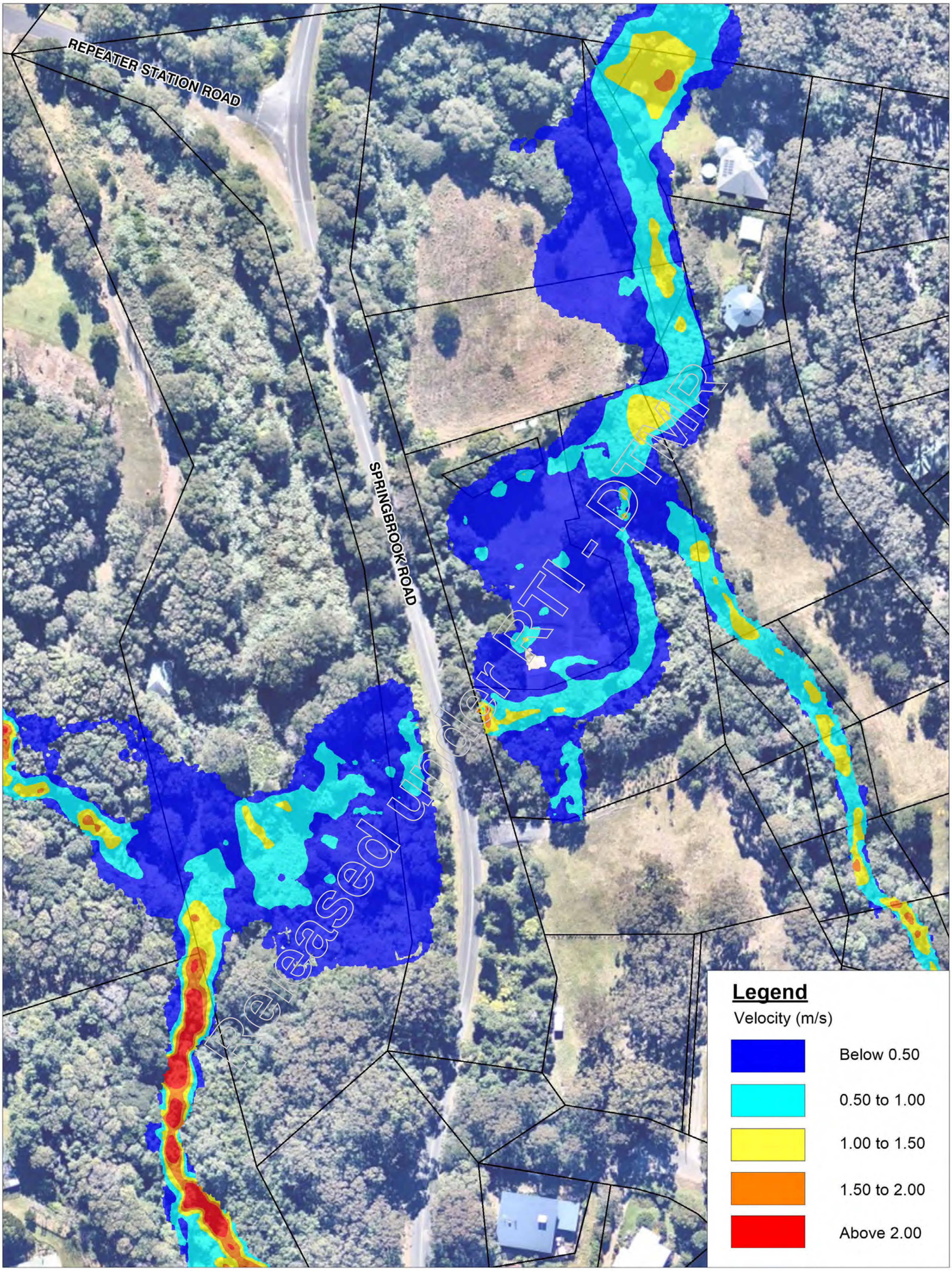

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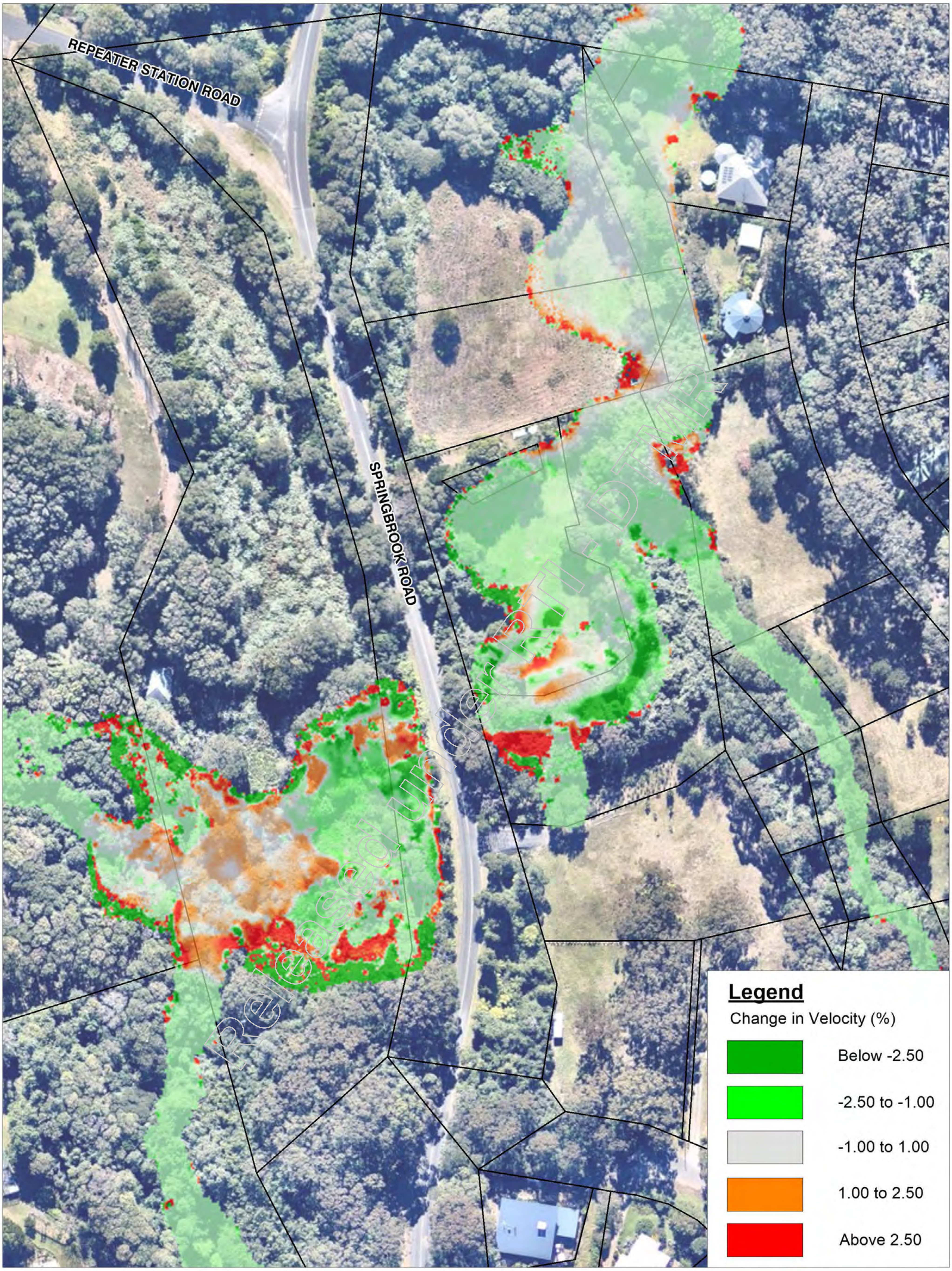

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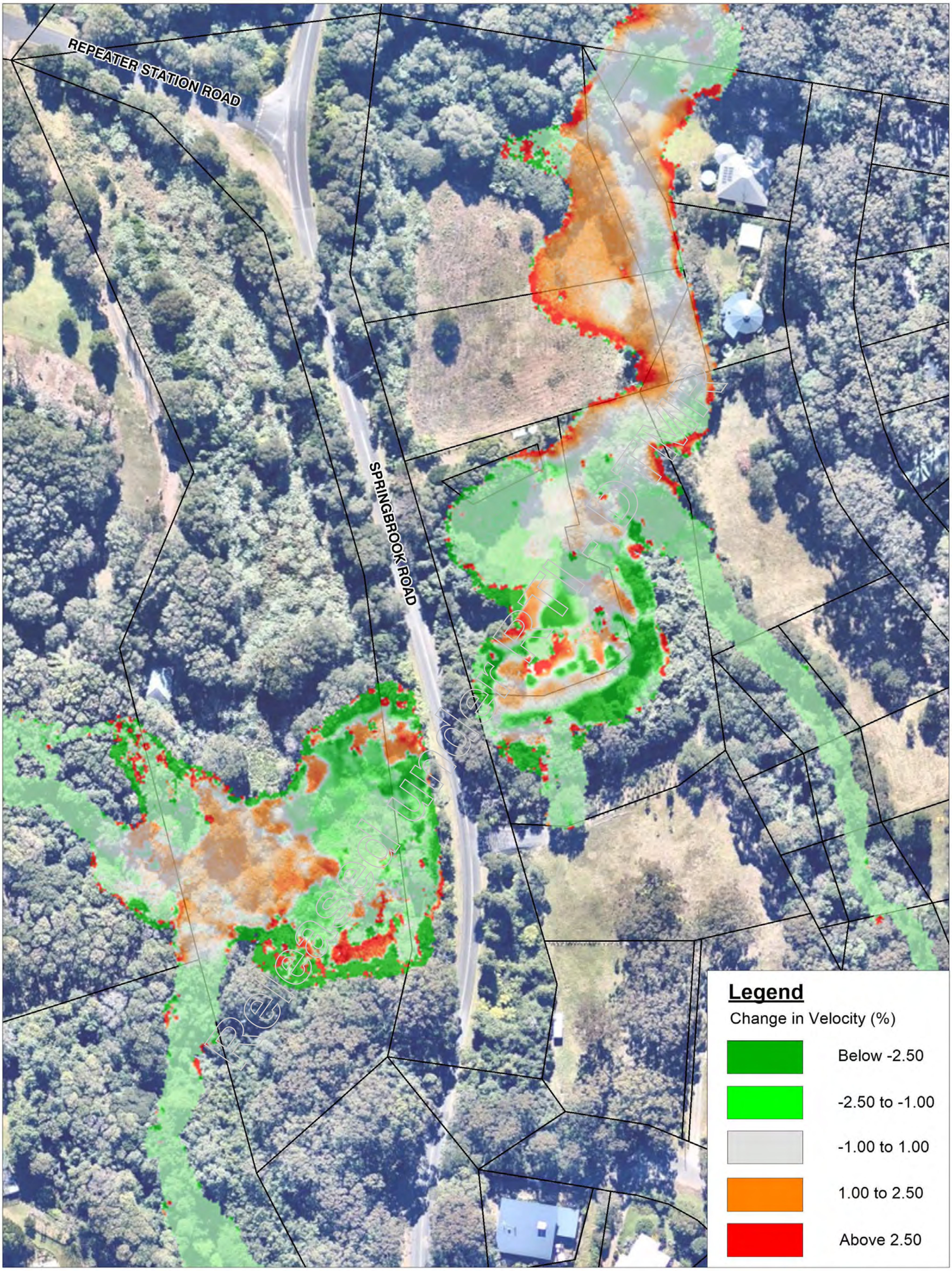

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DRAWING NO. 05_LilNerang_Velocity_D04e_D04_2%_001

CREATED BY not relevant

DATE 27/09/2018

STATUS ISSUE

REVISION A

PROJECT NO. 30032217

PROJECT TITLE LITTLE NERANG CREEK CULVERT REMEDIATION

TITLE

CHANGE IN VELOCITY MAP - 2% AEP D04e (4/1280mm CSP) vs. D04 (4/1200mm RCP)

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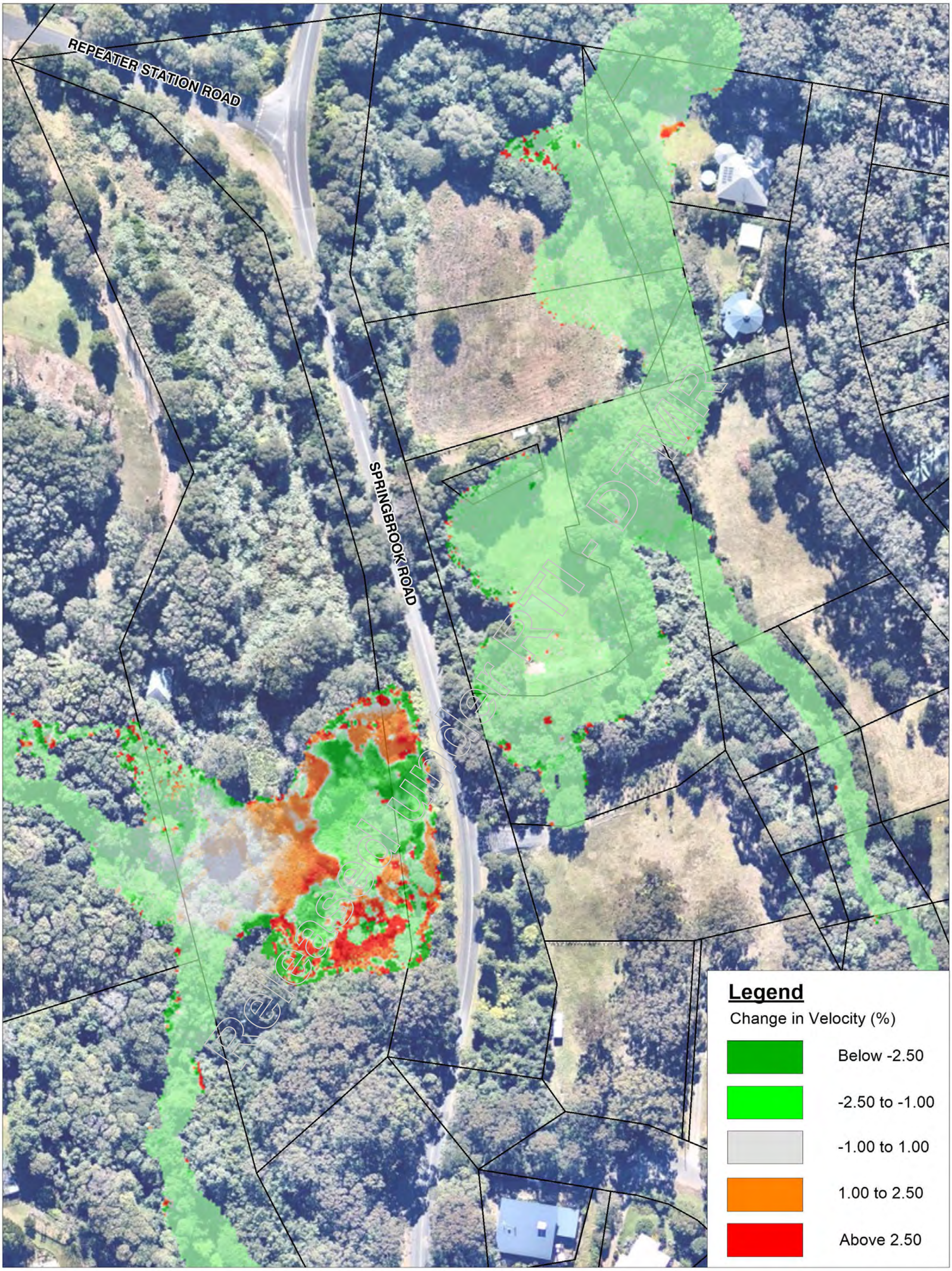

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CREATED BY not relevant

DATE 27/09/2018

STATUS ISSUE

REVISION A

PROJECT NO. 30032217

PROJECT TITLE LITTLE NERANG CREEK CULVERT REMEDIATION

TITLE CHANGE IN VELOCITY MAP - 5% AEP D04e (4/1280mm CSP) vs. D04 (4/1200mm RCP)

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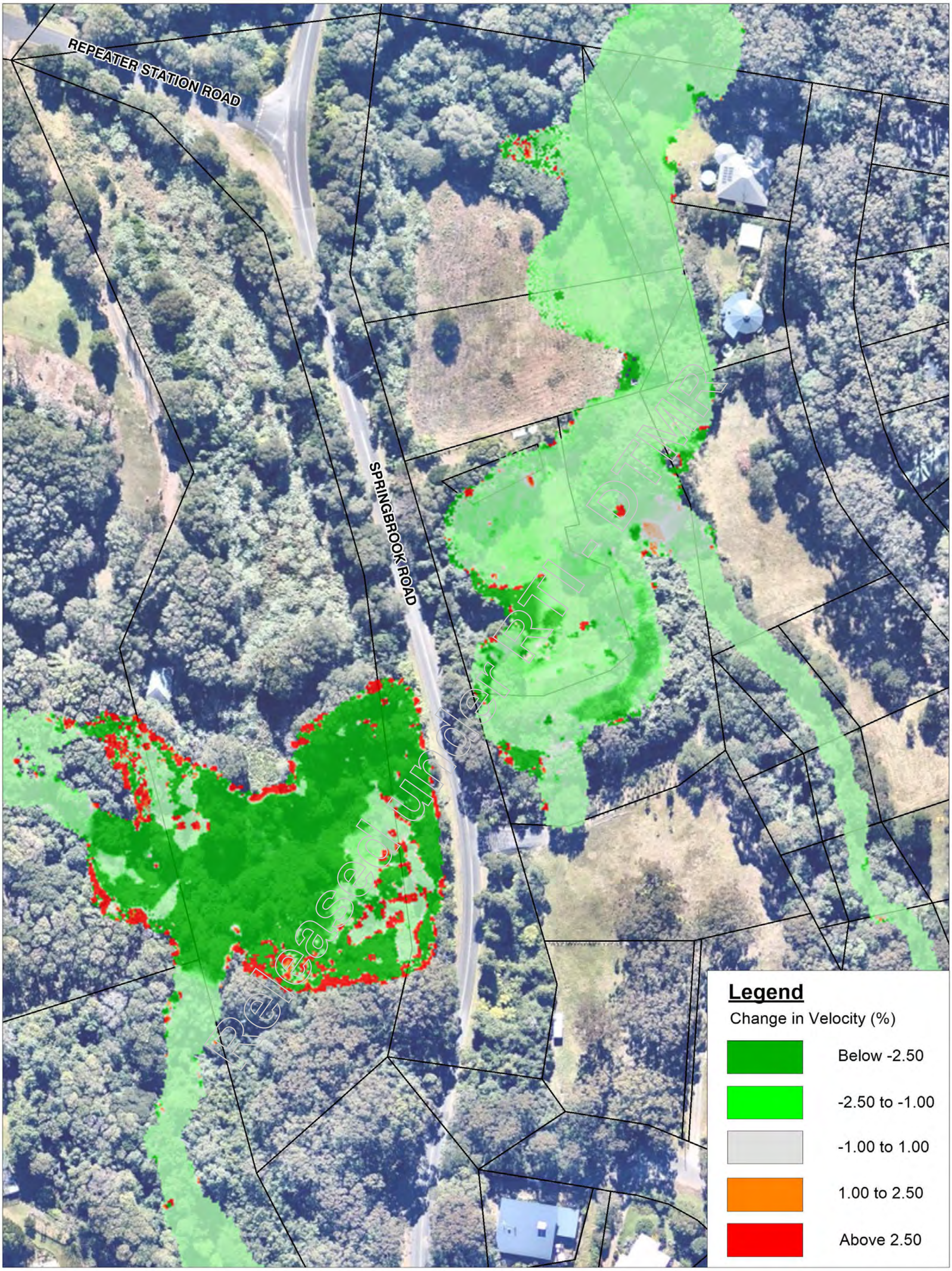

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DRAWING NO. 07_LilNerang_Velocity_D04e_D04c_1%_001

CREATED BY not relevant

DATE 21/09/2018

STATUS ISSUE

REVISION A

PROJECT NO. 30032217

PROJECT TITLE LITTLE NERANG CREEK CULVERT REMEDIATION

TITLE

CHANGE IN VELOCITY MAP - 1% AEP D04e (4/1280mm CSP) vs. D04c (3/1350mm RCP)

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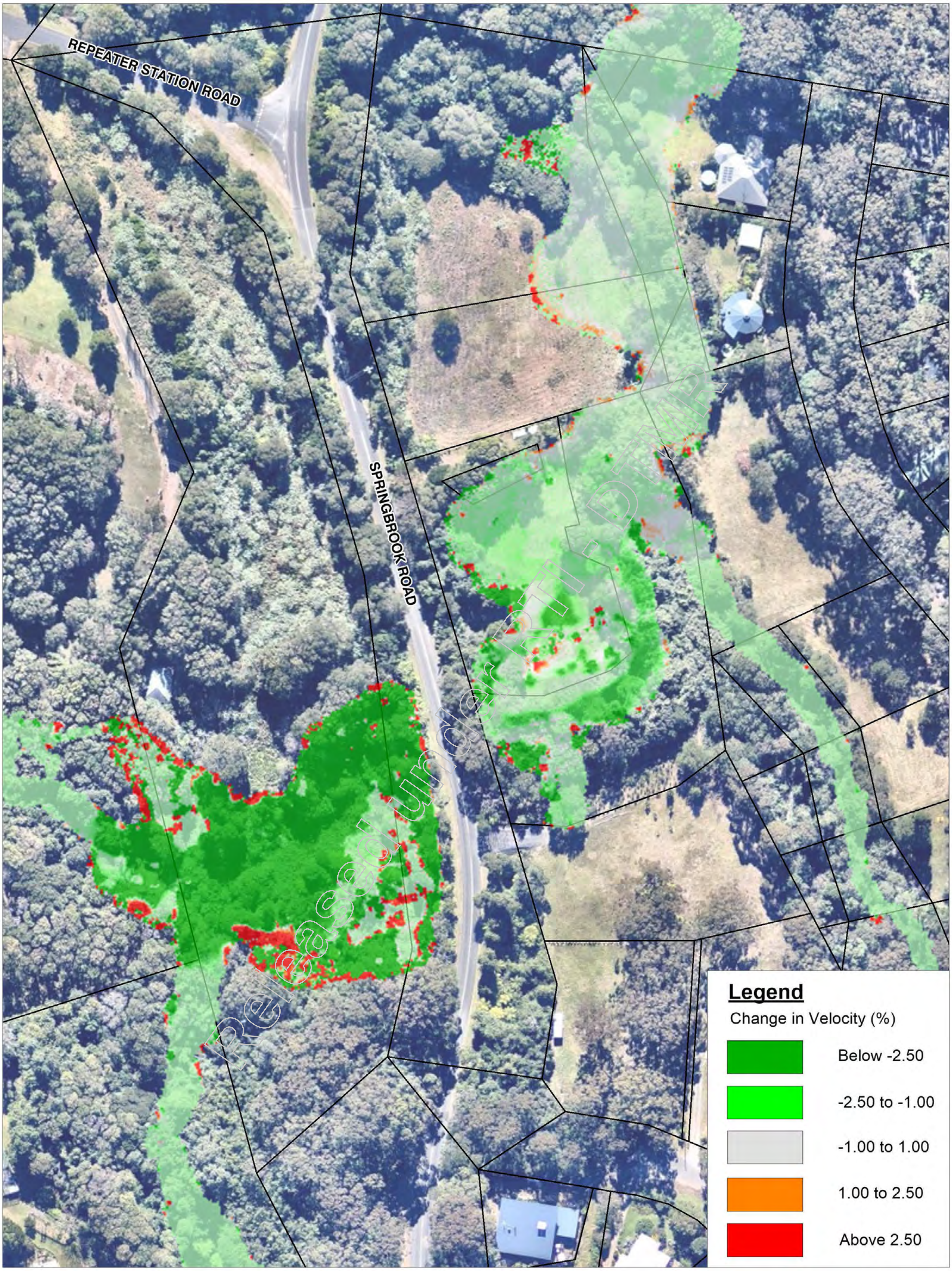

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DATE 21/09/2018

STATUS ISSUE

REVISION A

PROJECT NO. 30032217

PROJECT TITLE LITTLE NERANG CREEK CULVERT REMEDIATION

TITLE

CHANGE IN VELOCITY MAP - 2% AEP D04e (4/1280mm CSP) vs. D04c (3/1350mm RCP)

CLIENT

Queensland Government
Department of Main Roads

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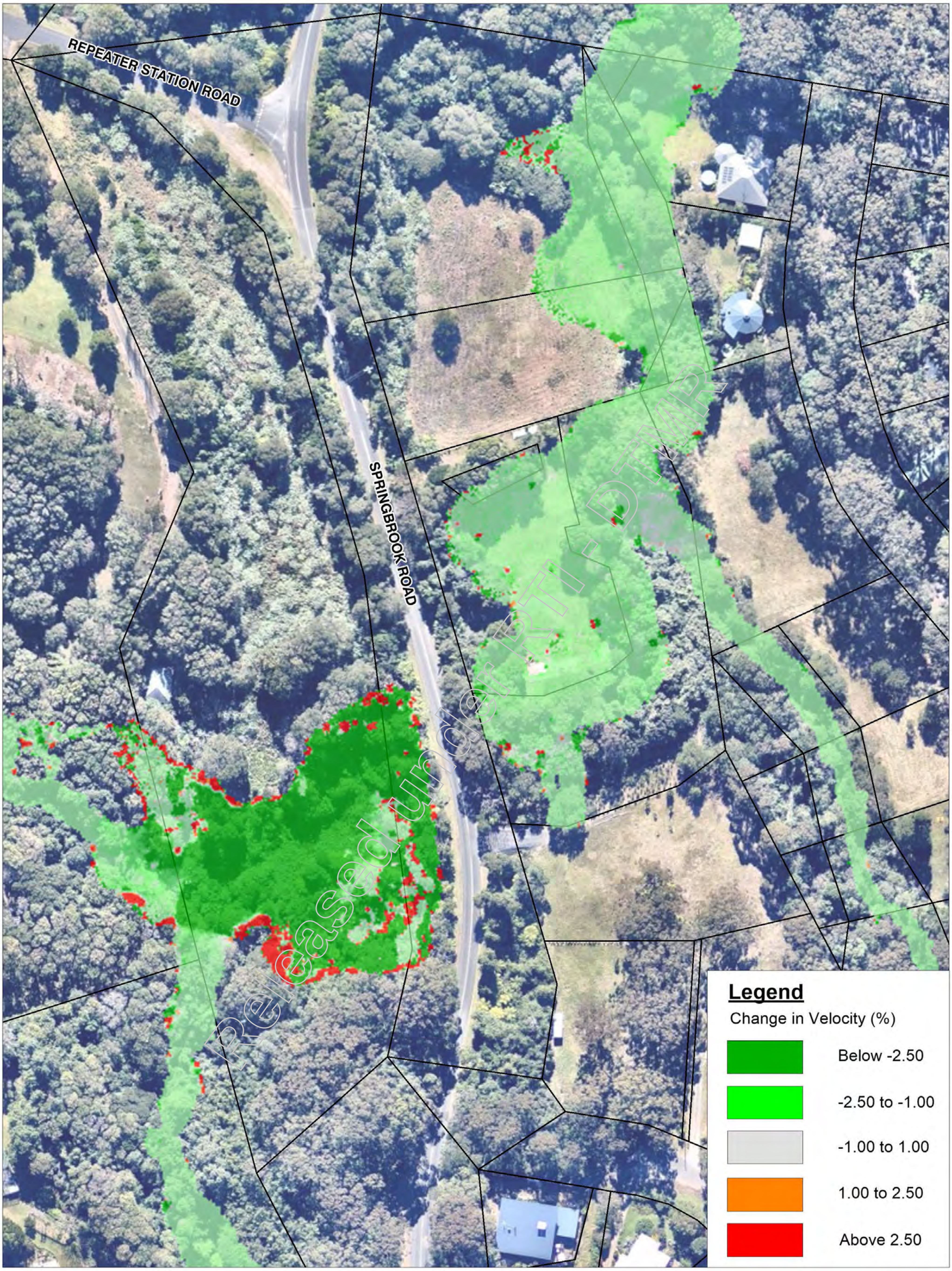

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DATE 27/09/2018

STATUS ISSUE

REVISION A

PROJECT NO. 30032217

PROJECT TITLE LITTLE NERANG CREEK CULVERT REMEDIATION

TITLE

CHANGE IN VELOCITY MAP - 5% AEP D04e (4/1280mm CSP) vs. D04c (3/1350mm RCP)

CLIENT

Queensland Government
Department of Main Roads

CONSULTANT

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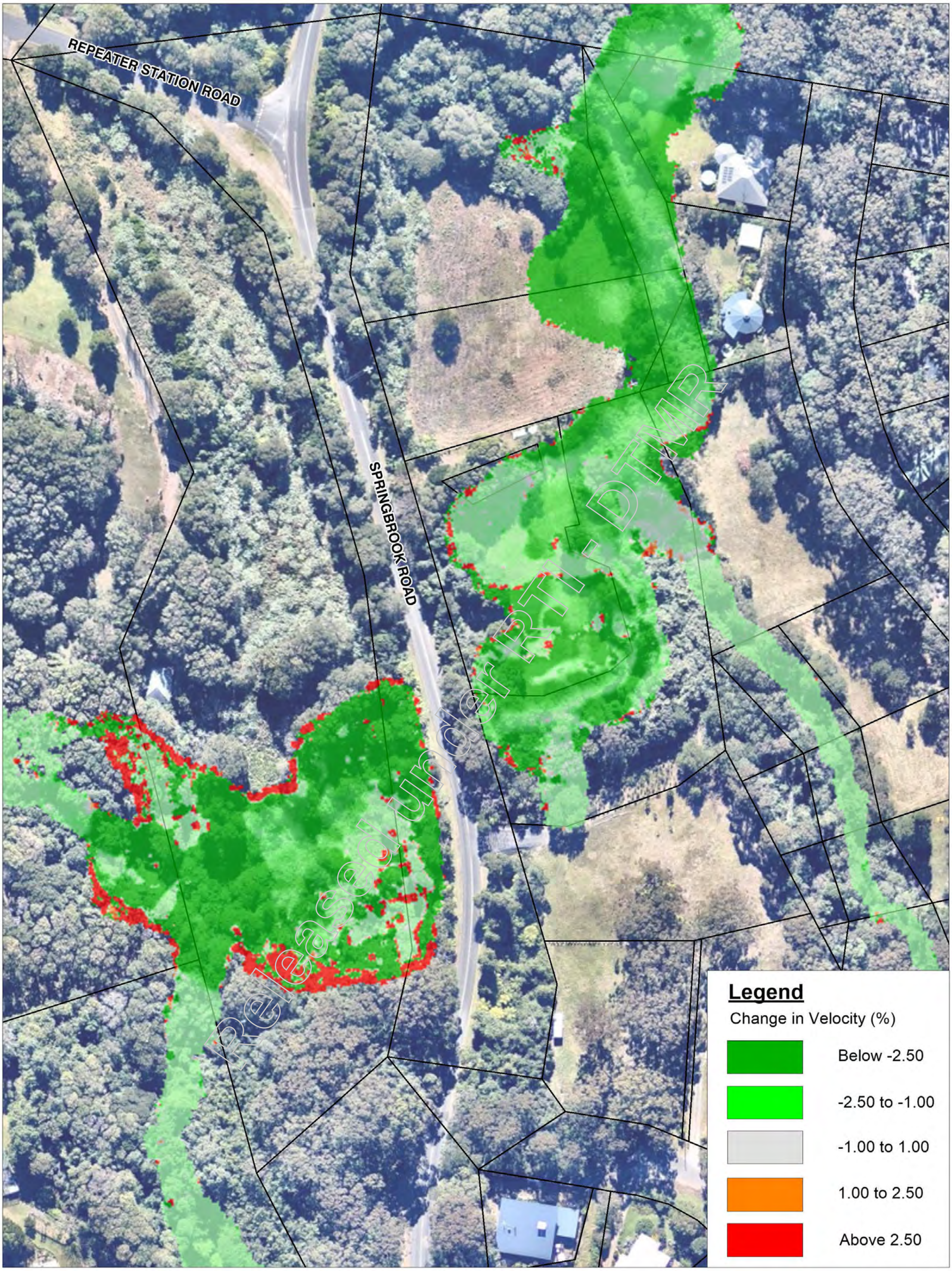

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COORDINATE SYSTEM Datum: GDA94 Projection: MGA Zone 56

DRAWING NO. 10_LilNerang_Velocity_D04e_D04f_1%_001

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DATE 27/09/2018

STATUS ISSUE

REVISION A

PROJECT NO. 30032217

PROJECT TITLE LITTLE NERANG CREEK CULVERT REMEDIATION

TITLE **CHANGE IN VELOCITY MAP - 1% AEP D04e (4/1280mm CSP) vs. D04f (4/1200mm RCP with 20% Blockage)**

CLIENT

Queensland Government
Department of Main Roads

CONSULTANT

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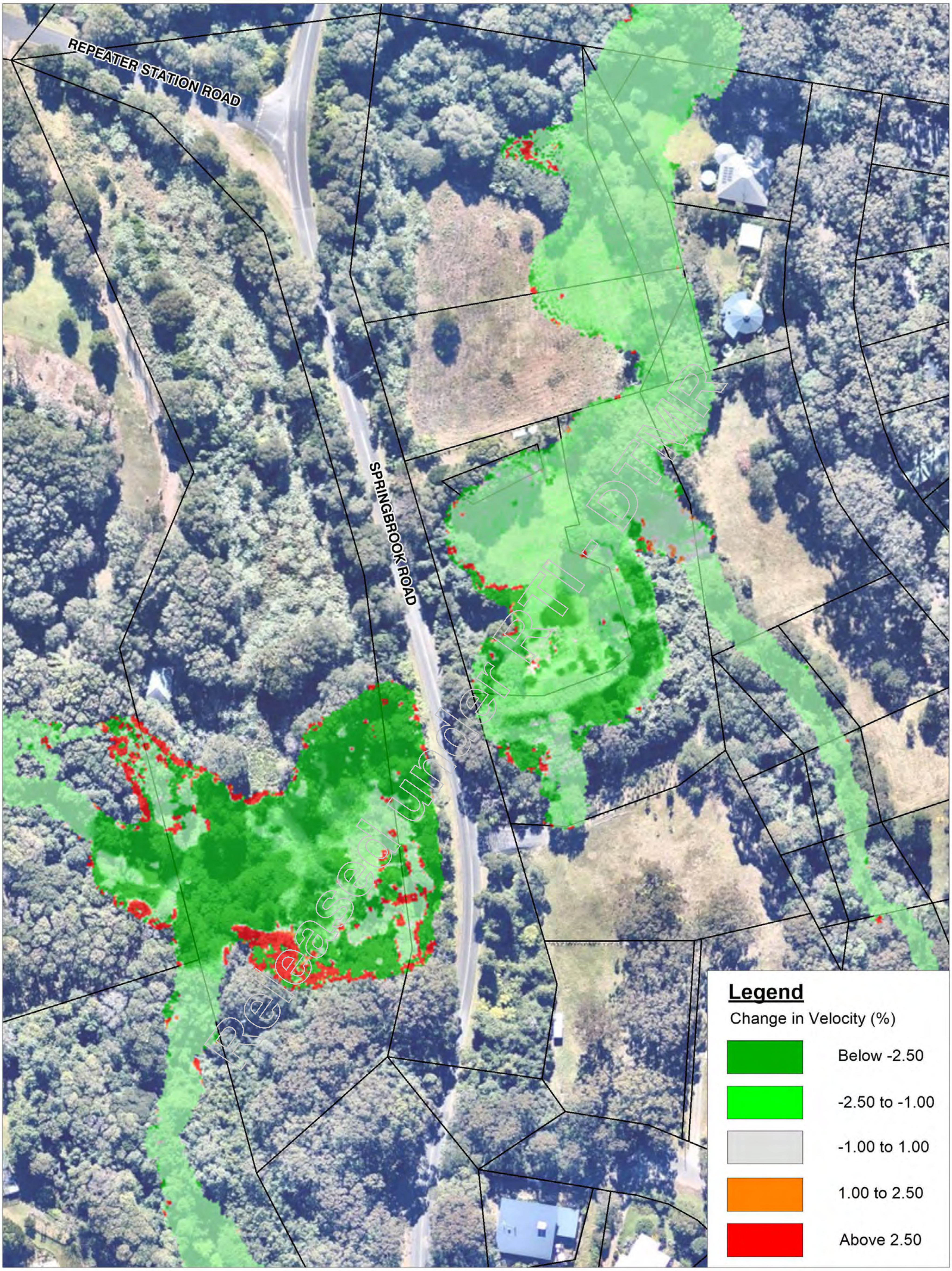

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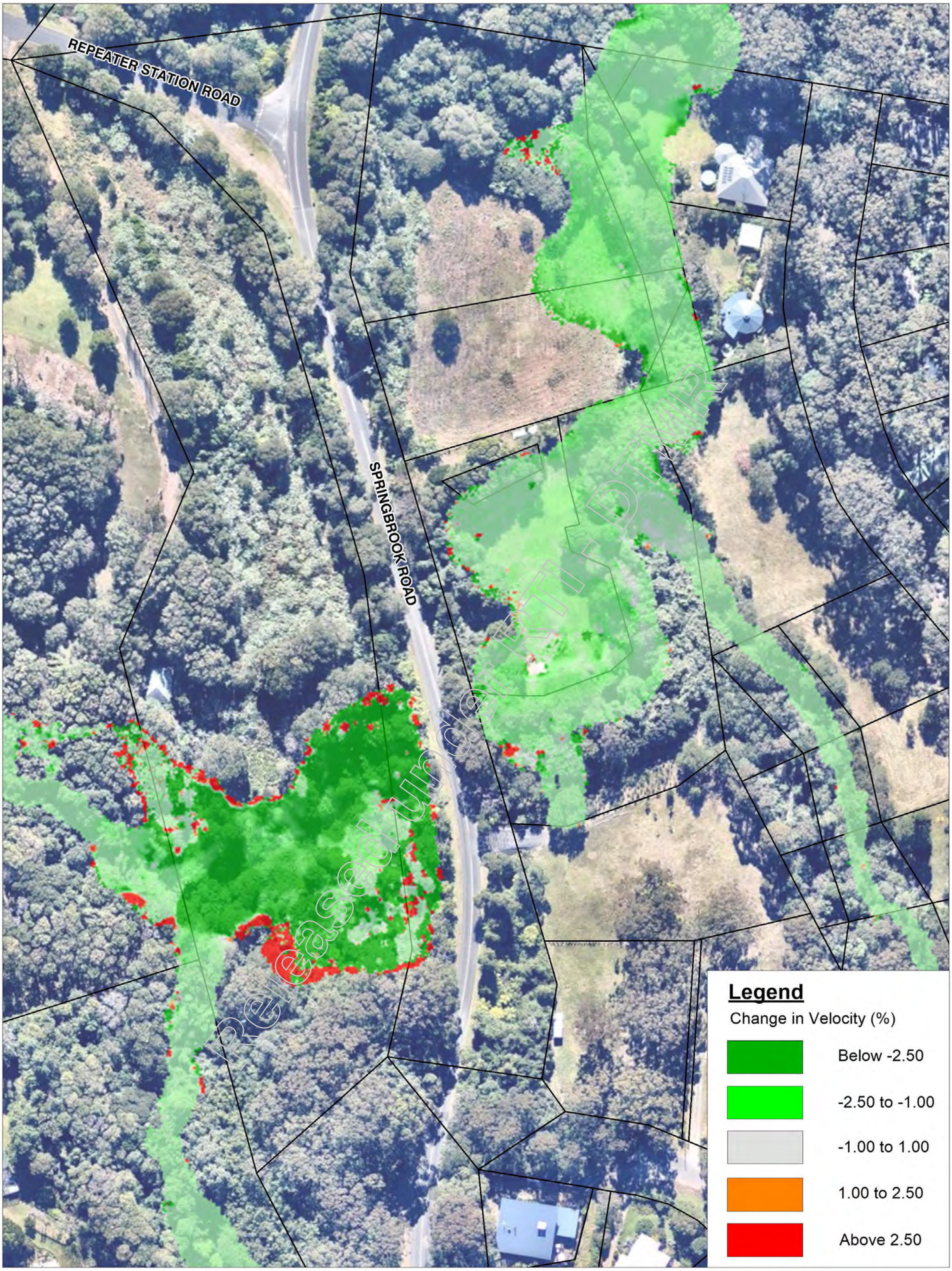
			CONSULTANT SMEC SMEC Australia Ltd Level 1, 154 Melbourne Street South Brisbane QLD 4101



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Gold Coast – Springbrook Road Culvert Replacement
Technical Note

Technical Note No.:	001	**Date:**	20 July 2018
Title:	Culvert flood immunity assessment		
Reference:	TMR Briefing data – Site Photographs and Concept Design Drawing		
Discipline:	Water Resources		
Originator:	not relevant	**Rev.:**	01
Reviewer:	not relevant	**Approved:**	not relevant

1 INTRODUCTION

The Department of Transport and Main Roads (TMR) engaged SMEC Australia Pty Ltd (SMEC) to investigate the replacement of culverts located on Little Nerang Creek and passing under Gold Coast Springbrook Road. The culverts are adjacent to Lot 4/SP260690 at approximate coordinates -28.2166 latitude and 153.2696 longitude (refer Figure 1-1).

The existing culverts consist of four 1280mm diameter corrugated steel pipes (CSP), which have become heavily corroded. The corrosion, in combination with undercutting or piping underneath the culvert apron, has led to a channel that cuts through the invert and along the full length of the culvert (refer Plate 1). Temporary shoring and displacement of jointing has also occurred (refer Plate 2) and it is understood that the culverts are to be replaced.

Figure 1-1 Location of Culverts

Plate 1 Condition of Existing Culverts

Plate 2 Temporary Shoring and Displacement

2 PURPOSE

The purpose of this technical note is to:

- Estimate the current level of flood immunity at the culvert crossing; and
- Provide culvert arrangement options based on afflux and immunity impacts.

3 DATA SOURCES

The following data were applied to the assessment herein:

- Aerial Laser Survey (ALS) derived 1m Digital Elevation Model (DEM), provided by TMR;
- TMR 2015 culvert replacement concept design drawing (SK001 (A)); and
- Culvert survey (2015) conducted by Bennett and Bennett (Contract number MR101001).

4 CALUCLATION METHOD AND RESULTS

The contributing catchment was delineated using the ALS derived 1m DEM and estimated to be 0.56 km^2. Rational Method was applied to estimate peak flows arriving at the culvert (refer Table 4-1) for standard magnitude events up to and including the 100 year Average Recurrence Interval. The Bransby Williams method was adopted for estimating the catchment time of concentration of 34.5 minutes.

Table 4-1 Rational Method Peak Discharge Summary

Variable	Average Recurrence Interval (years)						
	1	2	5	10	20	50	100
Frequency Factor	0.80	0.85	0.95	1.00	1.05	1.15	1.20
Intensity (mm/hr)	53.1	68.2	86.8	97.7	112.2	131.4	146.1
Discharge (m^3/s)	4.6	6.3	8.9	10.6	12.8	16.4	19.0

The Rational Method estimated peak discharges summarised in Table 4-1 were input to the HY-8 Culvert Hydraulic Analysis Program along with the road overtopping level, existing culvert size and arrangement, and downstream tailwater conditions. The findings of this analysis are presented in Table 4-2. The findings show that the road is immune from overtopping during the 100 year ARI peak discharge event. The culvert is shown to be outlet controlled and flowing full (Figure 4-1) during the 100 year ARI event and is only inlet controlled during low flows.

The analysis was updated using four 1200mm reinforced concrete pipes (RCP) as per the 2015 TMR concept design, which also showed no overtopping during the 100 year ARI event with a headwater depth of 752.21m.

Table 4-2 Hydraulic Analysis Summary – No Blockage

Average Recurrence Interval (years)	Overtopping Elevation (m)	Headwater Elevation (m)	Freeboard (mm)
1	752.25	749.92	233
2		750.18	207
5		750.43	182
10		750.59	166
20		750.82	143
50		751.41	84
100		751.93	32

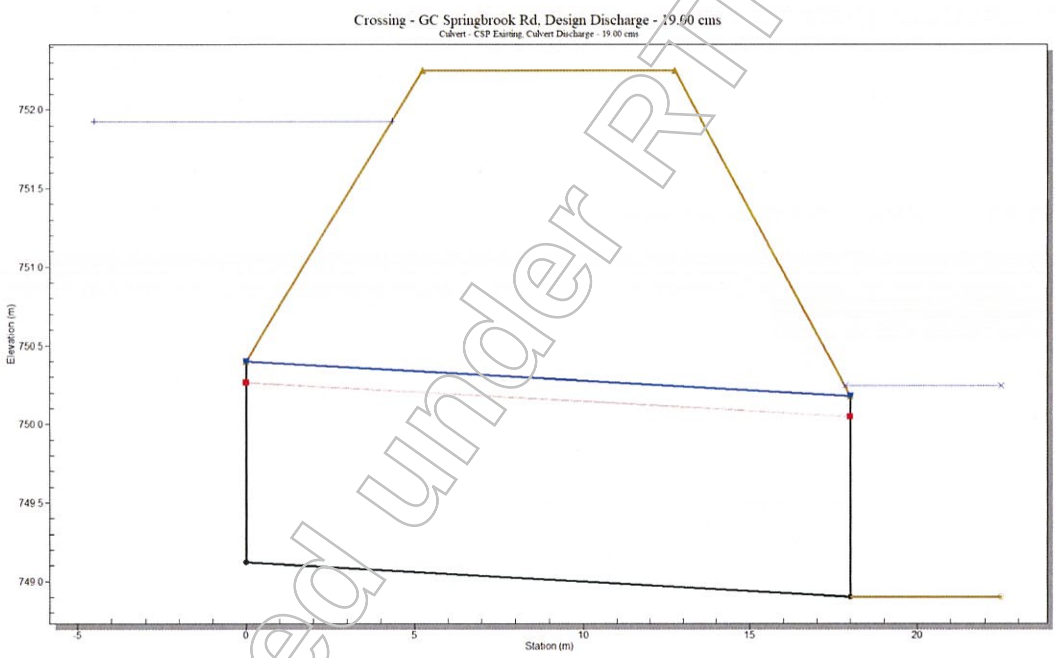

Figure 4-1 100 Year ARI Culvert Flow Regime – Outlet Controlled

5 SENSITIVITY ANALYSIS

The following analyses were performed to test sensitivity of results, namely:

- Applying 25% blockage to the culverts;
- Increasing the tailwater level; and
- Comparing Rational Method predicted flows against the Regional Flood Frequency Estimation (RFFE) Model.

The RFFE was investigated noting that the use of Rational Method is limited post release of Australian Rainfall and Runoff 2016. The RFFE however produced flows well above what could reasonably be expected for the catchment size and location and was discounted for use in this assessment. This decision was justified by the RFFE predicted flow per catchment area being well above the trend demonstrated by 1% Annual Exceedance Probability flood frequency analyses in all nearby stream gauges. Furthermore, the RFFE lower bound was consistently above the Rational Method predicted peak flows.

Applying 25% blockage to the culvert structure was estimated to reduce the crossing flood immunity to a 20 year ARI (refer Table 5-1). The 50 year and 100 year ARI reported overtopping depths are not considered accurate as the overtopping cross section is not known in detail. It was determined that adding another 1280mm CSP (5 barrels total) at 25% blockage increased the flood immunity to a 50 year ARI.

Table 5-1 Hydraulic Analysis Summary – 25% Blockage

Average Recurrence Interval (years)	Overtopping Elevation (m)	Headwater Elevation (m)	Freeboard (mm)
1	752.25	750.06	219
2		750.26	199
5		750.60	165
10		750.98	127
20		751.52	73
50		752.33*	-8*
100		752.45*	-20*

*Headwater and overtopping depth not considered accurate due to lack of survey to define overtopping weir flow

Sensitivity to tailwater conditions was assessed for the existing culvert arrangement with zero blockage. This testing included flattening the downstream gradient by a factor of two from 1% to 0.5%, and increasing the channel manning's roughness value from 0.08 to 0.1. The culvert crossing flood immunity was found <u>not</u> to be impacted by flattening the gradient or increasing the channel roughness in isolation. However, if applied together there was found to be 1mm overtopping during the 100 year ARI event, which is well within the margin of cumulative error associated with the data sources and calculation methods.

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6 CONCLUSION

Assessment of the Little Nerang Creek culverts passing under Gold Coast Springbrook Road determined that the culverts have a current 100 year ARI level of immunity. Further analysis showed that the immunity results are sensitive to the blockage factor assumed, with 25% blockage resulting in a reduced flood immunity of a 20 year ARI. Due to the dense vegetation within the contributing catchment and likely blockage during flooding, it is recommended that the culvert capacity be maintained during replacement at a minimum to provide an estimated 20 year ARI level of immunity at 25% blockage. Consideration should be given to adding another culvert barrel during the replacement to achieve 50 year ARI flood immunity with 25% blockage.

A RCP replacement of simular capacity can be considered. The RCP has a lower roughness than CSP and as such losses through the culvert are reduced for a given flow area and discharge. Further consideration should be given to material type and the application of a suitable apron with cut-off wall during the design phase.

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Gold Coast – Springbrook Road Little Nerang Creek Culvert Replacement

Technical Note

Technical Note No.:	002	**Date:**	15 August 2018
Title:	1350mm RCP and 1500mm RCP Pipe Jacking Hydraulic Performance Comparison		
Reference:	TMRSCR073/18 Little Nerang Creek Culvert Replacement		
Discipline:	Water Resources		
Originator:	not relevant	**Rev.:**	01
Reviewer:	not relevant	**Approved:**	not relevant

1 INTRODUCTION

The Queensland Department of Transport and Main Roads (TMR) engaged SMEC Australia Pty Ltd (SMEC) to investigate the replacement of culverts located on Little Nerang Creek and passing under Gold Coast Springbrook Road. The culverts are adjacent to Lot 4/SP260690 at approximate coordinates -28.2166 latitude and 153.2696 longitude (refer Figure 1-1).

The existing culvert crossing consists of 4 No. 1280mm Corrugated Steel Pipes (CSP), which have become heavily corroded and accordingly are proposed to be replaced. It is understood that larger pipe diameters of either 1350mm or 1500mm diameter are proposed for the culvert replacement works, due to the change in construction methodology from conventional trench excavation to pipe jacking.

Figure 1-1 Location of Culverts

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1.1 Previous Studies

SMEC initially conducted a flood immunity assessment for the existing culvert crossing documented in Technical Note: *30031652-TN-001 Gold Coast Springbrook Road - Culvert Replacement*, which should be read in conjunction with this document. The main findings of the initial flood immunity assessment are as follows:

- The existing culvert crossing consists 4 No. 1280mm (CSP)
- The existing flood immunity is approximately a 100 year Average Recurrence Interval (ARI) with no blockage
- Sensitivity analysis showed the existing culvert flood immunity reduces to a 20 year ARI when 25% blockage is applied
- Consideration should be given to increasing capacity to improve flood immunity under the 25% blockage scenario, given the heavily timbered catchment
- Consideration should be given to replacing the CSP culverts with Reinforced Concrete Pipes (RCP), which have a lower roughness than CSP and are therefore more hydraulically efficient at flow conveyance

2 PURPOSE

The purpose of this Technical Note is to:

- Benchmark the hydraulic performance of 4 No. 1350mm and 1500mm RCP culvert arrangements against the "like-for-like" replacement consisting 4 No. 1200 RCP
- Document the hydraulic performance for each option, providing recommendation on the culvert arrangement to adopt for pipe jacking

3 DATA SOURCES

The following data were applied to the assessment herein:

- Aerial Laser Survey (ALS) derived 1m Digital Elevation Model (DEM), provided by TMR;
- TMR 2015 culvert replacement concept design drawing (SK001 (A)); and
- Culvert survey (2015) conducted by Bennett and Bennett (Contract number MR101001).

4 CALUCLATION METHOD AND RESULTS

The following sections document the hydrologic and hydraulic methods and results for estimating peak design discharges and the hydraulic performance of various culvert arrangements, respectively.

4.1 Hydrologic Assessment

The contributing catchment was delineated using the ALS derived 1m DEM and estimated to be 0.56 km^2. The Rational Method was applied to estimate peak flows arriving at the culvert (refer Table 4-1) for standard magnitude events up to and including the 100 year Average Recurrence Interval. The Bransby Williams method was adopted for estimating the catchment time of concentration of 34.5 minutes.

Table 4-1 Rational Method Peak Discharge Summary

Variable	Average Recurrence Interval (years)						
	1	2	5	10	20	50	100
Frequency Factor	0.80	0.85	0.95	1.00	1.05	1.15	1.20
Intensity (mm/hr)	53.1	68.2	86.8	97.7	112.2	131.4	146.1
Discharge (m^3/s)	4.6	6.3	8.9	10.6	12.8	16.4	19.0

4.2 Hydraulic Performance Assessment

The Rational Method estimated peak discharges summarised in Table 4-1 were input to the HY-8 Culvert Hydraulic Analysis Program along with the road overtopping level, culvert size and arrangement, and downstream tailwater conditions. Several culvert replacement options were then assessed and the hydraulic performance compared between options. The analysis findings are presented in Table 4-2 for the no blockage scenario. Subsequent to this analysis, a 25% blockage factor was applied to all modelled scenarios to determine the sensitivity of the results to blockage with the results presented in Table 4-3.

The results generally show that:

- Increasing the pipe diameter from 1200mm to 1500mm results in an increase in freeboard and a decrease in outlet velocity
- Outlet velocities for the 100 year ARI event range from approximately 3.5m/s to 4.5m/s, depending on the pipe size and blockage scenario adopted
- The 4 No. 1200, 1350 and 1500 RCP arrangements all provide 100 year ARI flood immunity for the no blockage scenario
- The following flood immunity is achieved for various pipe sizes under the 25% blockage scenario:
    - 4 No. 1200 RCP – 20 year ARI
    - 4 No. 1350 RCP – 50 year ARI
    - 4 No. 1500 RCP – 100 year ARI

Table 4-2 Hydraulic Analysis Summary – No Blockage

Average Recurrence Interval (years)	Overtopping Elevation (m)	4 No. 1200 RCP			4 No. 1350 RCP			4 No. 1500 RCP		
		Headwater Elevation (m)	Freeboard (mm)	Outlet Velocity (m/s)	Headwater Elevation (m)	Freeboard (mm)	Outlet Velocity (m/s)	Headwater Elevation (m)	Freeboard (mm)	Outlet Velocity (m/s)
1	752.25	749.97	228	2.91	749.91	234	2.86	749.87	238	1.22
2		750.15	210	3.13	750.09	216	3.08	750.03	222	3.03
5		750.43	182	3.41	750.32	193	3.34	750.25	200	3.28
10		750.64	161	3.58	750.47	178	3.48	750.38	187	3.42
20		750.95	130	3.79	750.68	157	3.67	750.54	171	3.58
50		751.62	63	4.15	751.08	117	3.95	750.83	142	3.82
100		752.21	4	4.20	751.44	81	4.15	751.06	119	3.99

Table 4-3 Hydraulic Analysis Summary – 25% Blockage

Average Recurrence Interval (years)	Overtopping Elevation (m)	4 No. 1200 RCP			4 No. 1350 RCP			4 No. 1500 RCP		
		Headwater Elevation (m)	Freeboard (mm)	Outlet Velocity (m/s)	Headwater Elevation (m)	Freeboard (mm)	Outlet Velocity (m/s)	Headwater Elevation (m)	Freeboard (mm)	Outlet Velocity (m/s)
1	752.25	750.04	221	2.97	749.98	227	2.92	749.93	232	2.88
2		750.27	198	3.21	750.17	208	3.14	750.11	214	3.09
5		750.7	155	3.54	750.46	179	3.43	750.35	190	3.36
10		751.07	118	3.13	750.69	156	3.61	750.51	174	3.51
20		751.66	59	3.77	751.05	120	3.83	750.75	150	3.70
50		752.37	0	4.42	751.79	46	3.82	751.22	103	4.00
100		752.48	0	4.51	752.31	0	4.31	751.65	60	3.58

5 CONCLUSION AND RECOMENDATIONS

Hydraulic assessment of the Little Nerang Creek culvert replacement solutions showed that the RCP diameter adopted impacts both the freeboard and outlet velocity for the no blockage scenario, and impacts the flood immunity for the 25% blockage scenario. Considering the catchment is heavily timbered, taking the 25% blockage scenario as the design case carries merit.

On this basis, the pipe size adopted is largely a function of the desired flood immunity. Should a 50 year ARI immunity be satisfactory, then the 4 No. 1350 RCP arrangement should be adopted. If a 100 year ARI immunity warrants the increase in associated construction cost, then the 4 No. 1500 RCP should be adopted.

It is worth noting that the 1500 RCP option has the added benefit of decreased outlet velocities for most design discharges. Outlet velocities >3.5m/s will likely result in excessive scour and potential undercutting of the hydraulic structure. Further consideration should therefore be given to the application of a suitable apron with cut-off wall in combination with adopting a larger diameter pipe. If rock apron protection is proposed, the apron would likely extend beyond the road corridor boundary for the 50 to 100 year ARI design velocities and the rock size be such that a rock mattress type arrangement would likely be more economical.

Gold Coast – Springbrook Road Little Nerang Creek Culvert Replacement

Technical Note

Technical Note No.:	003	**Date:**	07 September 2018
Title:	1200mm RCP, 1350mm RCP and 1500mm RCP Afflux Assessment		
Reference:	TMRSCR073/18 Little Nerang Creek Culvert Replacement		
Discipline:	Water Resources		
Originator:	not relevant	**Rev.:**	0
Reviewer:	not relevant	**Approved:**	not relevant

1 INTRODUCTION

The Queensland Department of Transport and Main Roads (TMR) engaged SMEC Australia Pty Ltd (SMEC) to investigate the replacement of culverts located on Little Nerang Creek and passing under Gold Coast Springbrook Road. The culverts are adjacent to Lot 4/SP260690 at approximate coordinates -28.2166 latitude and 153.2696 longitude (refer Figure 1-1).

The existing culvert crossing consists of 4 No. 1280mm Corrugated Steel Pipes (CSP), which have become heavily corroded and accordingly are proposed to be replaced. It is understood that larger pipe diameters of either 1350mm or 1500mm diameter are proposed for the culvert replacement works, due to the change in construction methodology from conventional trench excavation to pipe jacking.

Figure 1-1: Location of Culverts

1.1 Previous Studies

SMEC initially conducted a flood immunity assessment for the existing culvert crossing documented in Technical Note: *30031652-TN-001 Gold Coast Springbrook Road - Culvert Replacement,* as well as a revised Technical Note: *30031652-TN-002 Little Nerang Creek Culvert Replacement - Pipe Jacking Hydraulic Comparison.* The main findings of the revised assessment are as follows:

- The 4 No. 1200, 1350 and 1500 Reinforced Concrete Pipe (RCP) arrangements all provide 1% Annual Exceedance Probability (AEP) flood immunity for the no blockage scenario
- The following flood immunity is achieved for various pipe sizes under the 25% blockage scenario:
  - 4 No. 1200 RCP – 18% AEP
  - 4 No. 1350 RCP – 2% AEP
  - 4 No. 1500 RCP – 1% AEP

TMR produced a Hydraulic Analysis report: *Little Nerang Creek Culvert Remediation,* which investigated the hydraulic performance of several mitigation options of the same culvert crossing, including:

- Option 1 – Line the culvert with 100mm of structural concrete
- Option 2 – Line the culvert with 200mm of structural concrete
- Option 3 – Line the culvert with a plastic liner and grouted annulus
- Option 4 – Remove and replace the culvert with a 4/1200 RCP.
- Option 5 – Construct a bridging structure retaining the existing culvert structure with minor repairs.
  - Option 5a – Outlet protection refinements; and
  - Option 5b – Consideration of failure of the existing culvert and surrounding soil.

Option 4 above forms the baseline for this assessment, refered to herein as option D04.

2 PURPOSE

The purpose of this Technical Note is to:

- Estimate the afflux, depth and velocity impact of the proposed 4/1350 RCP (D04a) and 4/1500 RCP (D04b) culvert arrangements against the baseline 4/1200 RCP (D04) arrangement; and
- Document the hydraulic performance for each option.

3 DATA SOURCES

The following data were applied to the assessment herein:

- TUFLOW Model and associated hydrographs, GIS models and Digital Elevation Model (DEM), provided by TMR; and
- Little Nerang Creek Culvert Remediation Hydraulic Analysis Report, provided by TMR.

4 CALUCLATION METHOD AND RESULTS

The following section documents the hydraulic method and results for estimating afflux, depth and velocity for the various culvert arrangements. Flood mapping is presented in Appendix A.

4.1 Hydrologic Assessment

It should be noted that the Australian Rainfall and Runoff 2016 (ARR16) derived hydrographs generated by the TMR URBS model were adopted in the assessment herein, not the City of Gold Coast (CoGC) derived hydrographs. A comparison between the ARR16, ARR87 and CoGC resultant hydrographs is provided in Figure 4-1 .

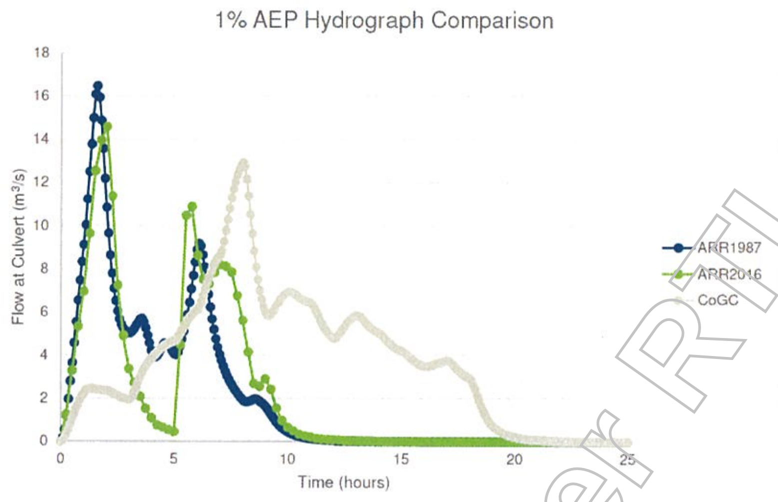

Figure 4-1: 1% AEP Hydrograph Comparison (TMR, 2017)

4.2 Hydraulic Assessment

The hydraulics assessment conducted for this project was completed using the 1D/2D hydraulic TUFLOW model received by TMR. The model was simulated using TUFLOW HPC and the results verified against TMR results. The received model was adopted as the base case model with the naming convention D04 and representing a 4/1200 RCP culvert crossing.

Two design case models were then simulated and the results compared to the baseline; namely D04a representing a 4/1350 RCP crossing and D04b representing a 4/1500mm RCP culvert crossing. The simulations were performed across the 18%, 5%, 2% and 1% AEP events.

The analysis findings are presented in Table 4-1 to Table 4-4 for a non-blockage scenario. Appendix A details the depth, velocity and afflux mapping for 18%, 5%, 2% and 1% AEP.

The results show:

- Minor impacts with 15mm and 17mm downstream afflux predicted for the 1% AEP for 1350mm and 1500mm pipes, respectively.
- An increase in pipe diameter has a negligible impact on the upstream and downstream velocity.
- The 4/1200, 4/1350 and 4/1500 RCP arrangements all provide 1% AEP flood immunity for a non-blockage scenario.

Table 4-1: 1% AEP Hydraulic Analysis – No Blockage

1% AEP	DIAMETER (mm)	VELOCITY (m/s)			DEPTH (m)		AFFLUX (mm)	
		UPSTREAM	CULVERT	DOWNSTREAM	Upstream	Downstream	UPSTREAM	CULVERT
D04	1200	1.05	3.11	1.83	2.16	2.40	-	-
D04a	1350	1.06	2.52	1.84	-	-	-199	15
D04b	1500	1.07	2.32	1.84	-	-	-279	17

Table 4-2: 2% AEP Hydraulic Analysis – No Blockage

2% AEP	DIAMETER (mm)	VELOCITY (m/s)			DEPTH (m)		AFFLUX (mm)	
		UPSTREAM	CULVERT	DOWNSTREAM	Upstream	Downstream	UPSTREAM	CULVERT
D04	1200	1.04	2.68	1.72	1.94	2.32	-	-
D04a	1350	1.06	2.30	1.73	-	-	-135	9
D04b	1500	1.06	2.19	1.73	-	-	-204	12

Table 4-3: 5% AEP Hydraulic Analysis – No Blockage

5% AEP	DIAMETER (mm)	VELOCITY (m/s)			DEPTH (m)		AFFLUX (mm)	
		UPSTREAM	CULVERT	DOWNSTREAM	Upstream	Downstream	UPSTREAM	CULVERT
D04	1200	1.03	2.26	1.60	1.67	2.22	-	-
D04a	1350	1.04	2.11	1.60	-	-	-74	1
D04b	1500	1.05	2.05	1.60	-	-	-122	3

Table 4-4: 18% AEP Hydraulic Analysis – No Blockage

18% AEP	DIAMETER (mm)	VELOCITY (m/s)			DEPTH (m)		AFFLUX (mm)	
		UPSTREAM	CULVERT	DOWNSTREAM	UPSTREAM	DOWNSTREAM	UPSTREAM	DOWNSTREAM
D04	1200	0.74	1.97	1.48	1.41	2.09	-	-
D04a	1350	0.76	1.89	1.49	-	-	-35	0.8
D04b	1500	0.81	1.81	1.49	-	-	-52	2

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5 CONCLUSION AND RECOMMENDATION

SMEC was engaged by the Queensland Department of Transport and Main Roads (TMR) to undertake a hydraulic assessment of the Little Nerang Creek culvert crossing under Gold Coast Springbrook Road.

The TUFLOW hydraulic assessment of the Little Nerang Creek culvert replacement solutions showed that adoption of 1350mm and 1500mm pipe diameters resulted 15mm to 17mm downstream afflux, respectively, compared to the 1200mm RCP results. Furthermore, the increase in pipe size had a negligible impact to outlet velocities for the 18%, 5%, 2% and 1% AEP events. For this reason, the constructability requirements should largely dictate pipe size selection for pipe jacking.

APPENDIX A MAPPING

Gold Coast – Springbrook Road Little Nerang Creek Culvert Replacement

Technical Note

Technical Note No.:	004	**Date:**	3 September 2019
Title:	4/1200mm; 3x1350mm; and 3/1500 RCP Afflux Assessment		
Reference:	TMRSCR073/18 Little Nerang Creek Culvert Replacement		
Discipline:	Water Resources		
Originator:	not relevant	**Rev.:**	3
Reviewer:	not relevant	**Approved:**	not relevant

1 INTRODUCTION

The Queensland Department of Transport and Main Roads (TMR) engaged SMEC Australia Pty Ltd (SMEC) to investigate the replacement of culverts located on Little Nerang Creek and passing under Gold Coast Springbrook Road. The culverts are adjacent to Lot 4/SP260690 at approximate coordinates -28.2166 latitude and 153.2696 longitude (refer Figure 1-1).

The existing culvert crossing consists 4/1280mm Corrugated Steel Pipes (CSP) arrangement, which have become heavily corroded and accordingly are proposed to be replaced. It is understood that larger pipe diameters of either 1350mm or 1500mm are proposed for the culvert replacement works, due to the change in construction methodology from conventional trench excavation to pipe jacking. Alternatively, a 4/1200 Reinforced Concrete Pipe (RCP) with grout infill arrangement has been proposed as a suitable alternative.

Figure 1-1: Location of Culverts

1.1 Previous Studies

SMEC initially conducted a flood immunity assessment for the existing culvert crossing documented in Technical Note: *30031652-TN-001 Gold Coast Springbrook Road - Culvert Replacement,* as well as revised Technical Notes *30031652-TN-002 Little Nerang Creek Culvert Replacement - Pipe Jacking Hydraulic Comparison* and *30031652-TN-003 Little Nerang Creek Culvert Replacement - Afflux Assessment*. The main findings of the second revised assessment are as follows:

- Minor impacts with 15mm and 17mm downstream afflux predicted for the 1% AEP for 4/1350mm and 4/1500mm pipes, respectively.
- An increase in pipe diameter has a negligible impact on the upstream and downstream velocity and results in a decrease in culvert velocity.
- The 4/1200, 4/1350 and 4/1500 RCP arrangements all provide 1% AEP flood immunity for a non-blockage scenario.

TMR provided a Hydraulic Analysis report: *Little Nerang Creek Culvert Remediation,* which investigated the hydraulic performance of several mitigation options for the steel culvert SID 64311. Accompanying the report was a working TUFLOW model with hydrographs outputs from an URBS hydrologic model based on Australian Rainfall and Runoff 2016 (ARR16) methods.

2 PURPOSE

The purpose of this Technical Note is to:

- Determine the afflux and change in velocity impact of the 4/1200 RCP (D04), 3/1350mm RCP (D04c), and 3/1500 RCP (D04d) arrangements against the baseline 4/1280 CSP (D04e) arrangement;
- Determine the amount of grout infill required to create non-worsening downstream for the 4/1200 RCP (D04f, D04G and D04h) arrangement against the baseline 4/1280 CSP (D04e) arrangement; and
- Document the hydraulic performance for each option and produce mapping for the 1%, 2% and 5% Annual Exceedance Probability (AEP) events.

3 DATA SOURCES

The following data were applied to the assessment herein:

- TUFLOW Model and associated hydrographs, GIS models and Digital Elevation Model (DEM), provided by TMR; and
- Little Nerang Creek Culvert Remediation Hydraulic Analysis Report, provided by TMR (HYD-1084-LNCC-REP-001-0).

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4 CALUCLATION METHOD AND RESULTS

The following section documents the hydraulic method and results for estimating afflux, depth and the change in velocity for the various culvert arrangements.

4.1 Hydrologic Assessment

It should be noted that the ARR16 derived hydrographs generated by the TMR URBS model were adopted in the assessment herein, not the City of Gold Coast (CoGC) derived hydrographs. A comparison between the ARR16, ARR87 and CoGC resultant hydrographs is provided in Figure 4-1.

Refer to the TMR Hydraulic Analysis report: *Little Nerang Creek Culvert Remediation* (HYD-1084-LNCC-REP-001-0) for further detail on the hydrologic model build and parameters.

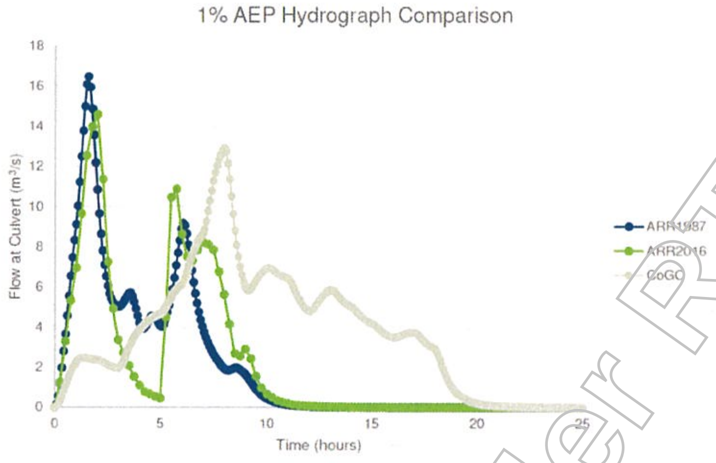

Figure 4-1: 1% AEP Hydrograph Comparison (TMR, 2017)

4.2 Hydraulic Performance Assessment

The hydraulics assessment conducted for this project was completed using the 1D/2D hydraulic TUFLOW model received from TMR. The model was simulated using TUFLOW HPC and the results verified against TMR results. The existing culverts were adopted as the base case model with the naming convention D04e and representing a 4/1280 CSP culvert crossing.

Several design case models were then simulated and the results compared to the existing; namely:

- D04 representing a 4/1200 RCP crossing;
- D04c representing a 3/1350 RCP crossing;
- D04d representing a 3/1500 RCP crossing;
- Several 4/1200mm RCP arrangements (D04h, D04g, and D04f) with 10%, 15% and 20% grout infill to mitigate downstream afflux impacts; and
- D04j which models the internal diameter for DN1200 pipes as a 4/1165 RCP crossing.

The simulations were performed across the 5%, 2% and 1% AEP events. In all cases, the upstream and downstream culvert inverts were maintained to existing levels. The only changes made between the scenarios were the number of pipes, the pipe diameter and per cent blockage, and the pipe roughness coefficient with 0.024 applied to CSP and 0.013 applied to RCP.

The analysis findings are presented in Table 4-1 to Table 4-3. Appendix A details the depth, change in velocity and afflux mapping for 5%, 2% and 1% AEP events.

The results show:

- The 4/1200 RCP (D04) arrangement produces 6 mm and 12 mm afflux downstream for the 1% AEP and 2% AEP scenarios, respectively;
- The 3/1350 (D04c) arrangement achieves non-worsening downstream for the 1% and 5% AEP, however, produces 3mm downstream afflux for the 2% AEP event;
- The 3/1500 (D04d) arrangement produces 14 mm and 16 mm afflux downstream for the 1% AEP and 2% AEP scenarios, respectively;
- The 4/1200 RCP with 20% grout infill (D04f) by area is the only scenario which produces non-worsening downstream for the 2% AEP event;
- The 4/1200 RCP with 20% grout infill (D04f) by area produces the greatest upstream flood afflux and highest culvert velocity; and
- The 4/1200 RCP with 15% grout infill (D04g) by area produces similar results to the 3/1350 (D04c) arrangement.
- By modelling the 4/1165 (D04j) scenario, which is the internal diameter for DN1200 RCPs, downstream afflux is reduced from 6mm to 2mm for the 1% AEP event compared to the 4/1200 RCP (D04) scenario.

Mapping in Appendix A shows that by producing non-worsening downstream, significant upstream afflux is produced. Notwithstanding, there is approximately 2.5 m freeboard (estimated from LiDAR) to the dwelling located directly upstream of the culvert crossing for the 1% AEP event. Furthermore, the upstream afflux does not create significant increases in wetted area nor does it result in overtopping of the road for 1% AEP event.

It is important to note that the afflux mapping flood result marker (refer Appendix A) placed at the downstream property does not directly correlate to the downstream afflux values in the tables herein. This is due to the afflux tables reporting on values along the channel long section, whereas the flood marker reports on a single point result at the property. In general, the results agree within 1mm, and there is no change in the result trends between scenarios.

It should be noted that the downstream property of interest has not been surveyed for habitable floor level. From site investigation and photographs (contained in Appendix B) it is expected that the flood level of the main house structure is approximately 3m above existing surface. If required, detailed topographic survey can be carried out to confirm exact existing surface and floor level of the structure to confirm expected freeboard.

With the exception of the 4/1200 RCP (D04) scenario, both the downstream and upstream velocities are slightly reduced compared to existing by restricting peak discharge through the culverts for a given AEP event. This is due to attenuating flow upstream and reducing the peak discharge downstream. Higher changes in velocity are noted in the newly wetted regions or where flood depths have reduced and shallower water increases in velocity. In general, velocities of <1m/s are predicted at the downstream flood affected property between the various scenarios.

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Table 4-1: 1% AEP Hydraulic Analysis

1% AEP	DIAMETER (mm)	VELOCITY (m/s)			DEPTH (m)		AFFLUX (mm)	
		UPSTREAM	CULVERT	DOWNSTREAM	UPSTREAM	DOWNSTREAM	UPSTREAM	DOWNSTREAM
D04e	4x1280	1.05	2.71	1.82	2.26	2.39	-	-
D04	4x1200	1.04	3.11	1.82	-	-	-95	6
D04c	3x1350	1.03	3.24	1.80	2.37	2.42	92	-1
D04d	3x1500	1.04	2.69	1.83	-	-	-132	14
D04f	4x1200 (20% Blockage)	1.05	3.72	1.83	2.46	2.37	210	-14
D04g	4x1200 (15% Blockage)	1.06	3.56	1.84	2.36	2.38	105	-7
D04h	4x1200 (10% Blockage)	1.04	3.41	1.81	2.30	2.42	21	-2
D04J	4x1165 (DN1200 Internal Dia)	1.07	3.25	1.86	2.23	2.42	-43	2

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Table 4-2: 2% AEP Hydraulic Analysis

2% AEP	DIAMETER (mm)	VELOCITY (m/s)			DEPTH (m)		AFFLUX (mm)	
		UPSTREAM	CULVERT	DOWNSTREAM	UPSTREAM	DOWNSTREAM	UPSTREAM	DOWNSTREAM
D04e	4x1280	1.04	2.65	1.72	2.02	2.31	-	-
D04	4x1200	1.04	2.68	1.71	-	-	-74	12
D04c	3x1350	1.02	2.79	1.71	-	-	94	3
D04d	3x1500	1.05	2.45	1.77	-	-	-66	16
D04f	4x1200 (20% Blockage)	1.05	3.27	1.75	2.14	2.31	129	-2
D04g	4x1200 (15% Blockage)	1.03	3.11	1.71	2.09	2.34	59	3
D04h	4x1200 (10% Blockage)	1.06	2.96	1.76	2.04	2.34	3	7

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Table 4-3: 5% AEP Hydraulic Analysis

5% AEP	DIAMETER (mm)	VELOCITY (m/s)			DEPTH (m)		AFFLUX (mm)	
		UPSTREAM	CULVERT	DOWNSTREAM	UPSTREAM	DOWNSTREAM	UPSTREAM	DOWNSTREAM
D04e	4x1280	1.03	2.51	1.60	1.70	2.23	-	-
D04	4x1200	1.03	2.26	1.60	-	-	-27	1
D04c	3x1350	1.02	2.38	1.63	-	-	117	-1
D04d	3x1500	1.06	2.24	1.64	-	-	22	1
D04f	4x1200 (20% Blockage)	1.05	2.71	1.64	1.84	2.22	128	-2
D04g	4x1200 (15% Blockage)	1.06	2.56	1.64	1.80	2.25	83	-1
D04h	4x1200 (10% Blockage)	1.06	2.41	1.63	1.77	2.25	42	-3

1.1.1 Energy Dissipation and Scour Countermeasures

It is noted that culvert velocity is increased for all proposed culvert replacement scenarios except for the 3/1500 (D04d) arrangement, which was shown to produce unacceptable downstream afflux. A Froude number of approximately 1.0 was calculated at the culvert outlet for the various scenarios and a subcritical flow regime noted downstream. Austroads Guide to Road Design Part 5 recommends that for a Froude number of <1.7 a simple apron structure, riprap or flow expansion structure will suffice. Furthermore, it is noted in Austroads that energy dissipators sometimes create issues with debris and require ongoing maintenance.

A concrete apron with cut-off wall and riprap apron thereafter (space permitting) is an appropriate design solution considering the above factors. The riprap should be of D_{50} 300mm minimum, layered at 2 x D_{50} thickness and underlain with a geofabric with suitable puncture resistance. Should TMR wish to instate an energy dissipator structure, a Type B (horizontal roughness element) energy dissipator would be appropriate (refer Figure 4-2).

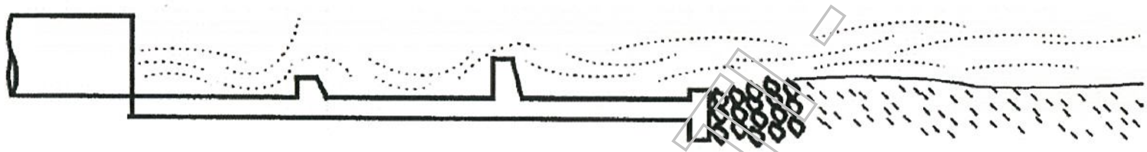

Figure 4-2: Type B energy dissipator (source: Alderson 2—6)

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5 CONCLUSION AND RECOMMENDATION

SMEC was engaged by the Queensland Department of Transport and Main Roads (TMR) to undertake a hydraulic assessment of the Little Nerang Creek culvert crossing under Gold Coast Springbrook Road. The assessment herein

The TUFLOW hydraulic assessment of the Little Nerang Creek culvert replacement solutions showed that only the 4/1200 RCP with 20% grout infill (D04f) by area resulted in non-worsening downstream for all AEP events assessed. This scenario is however more susceptible to blockage and resulted in the greatest upstream afflux. Furthermore, 1350 mm and 1500 mm diameters were preferred due to the ability to jack the pipes.

The 3/1350 RCP (D04c) arrangement produced non-worsening downstream except for the 2% AEP event, where 3mm afflux is predicted at the property downstream. There is no surveyed floor level for the dwelling downstream, however 3mm afflux is not considered to put at risk the habitable floor level due to the house being elevated on stilts.

The 3/1350 RCP (D04c) is recommended as the optimal arrangement considering the preferred construction method of pipe jacking, the minimal afflux created, and the reduction in velocities meaning no additional scour protection is required to produce non-worsening.

A concrete apron with cut-off wall is recommended as a scour protection measure at the culvert outlet. A riprap apron, extending from the concrete apron the road corridor boundary, would provide further protection and resist undercutting of the concrete apron. Alternatively, a Type B (horizontal roughness element) energy dissipater could be instated if an energy dissipation structure be deemed more appropriate.

NOTE: Subsequent to the above recommendation, advice was provided by TMR and their construction contractor, the 3/1350 RCP (D04c) was dismissed in favour of 4/1200 RCP as these could be jacked through the existing 4/1280 CSP (on the same alignment) meaning the existing embankment, formation and infill between culverts could remain intact. This resulted in a more constructible solution.

As discussed above, the 20% grout infill was dismissed due to the susceptibility to blockages. The actual internal diameter (1165mm) of the 1200 RCP's was modelled (D04j) for the 1% AEP scenario. Downstream afflux is reduced from 6mm to 2mm for the 1% AEP event compared to the 4/1200 RCP (D04) scenario. TMR consulted with the downstream property owner and advised that the resultant afflux was acceptable (refer email 15/10/2018).

Based on the above advice of constructability, landowner consultation and modelling of the actual internal diameter (1165) of the 1200 RCP, the preferred option is the 4/1200 RCP (D04j) as the optimal arrangement considering the preferred construction method of pipe jacking and the minimal afflux created (2mm in a 1% AEP event).

APPENDIX A MAPPING

DEPTH

01_LilNerang_Depth_D04e_1%_001

02_LilNerang_Depth_D04e_2%_001

03_LilNerang_Depth_D04e_5%_001

04_LilNerang_Depth_D04_1%_001

05_LilNerang_Depth_D04_2%_001

06_LilNerang_Depth_D04_5%_001

07_LilNerang_Depth_D04c_1%_001

08_LilNerang_Depth_D04c_2%_001

09_LilNerang_Depth_D04c_5%_001

10_LilNerang_Depth_D04f_1%_001

11_LilNerang_Depth_D04f_2%_001

12_LilNerang_Depth_D04f_5%_001

VELOCITY

01_LilNerang_Velocity_D04e_1%_001

02_LilNerang_Velocity_D04e_2%_001

03_LilNerang_Velocity_D04e_5%_001

04_LilNerang_Velocity_D04e_D04_1%_001

05_LilNerang_Velocity_D04e_D04_2%_001

06_LilNerang_Velocity_D04e_D04_5%_001

07_LilNerang_Velocity_D04e_D04c_1%_001

08_LilNerang_Velocity_D04e_D04c_2%_001

09_LilNerang_Velocity_D04e_D04c_5%_001

10_LilNerang_Velocity_D04e_D04f_1%_001

11_LilNerang_Velocity_D04e_D04f_2%_001

12_LilNerang_Velocity_D04e_D04f_5%_001

AFFLUX

01_LilNerang_Afflux_D04_D04e_1%_001

02_LilNerang_Afflux_D04_D04e_2%_001

03_LilNerang_Afflux_D04_D04e_5%_001

04_LilNerang_Afflux_D04c_D04e_1%_001

05_LilNerang_Afflux_D04c_D04e_2%_001

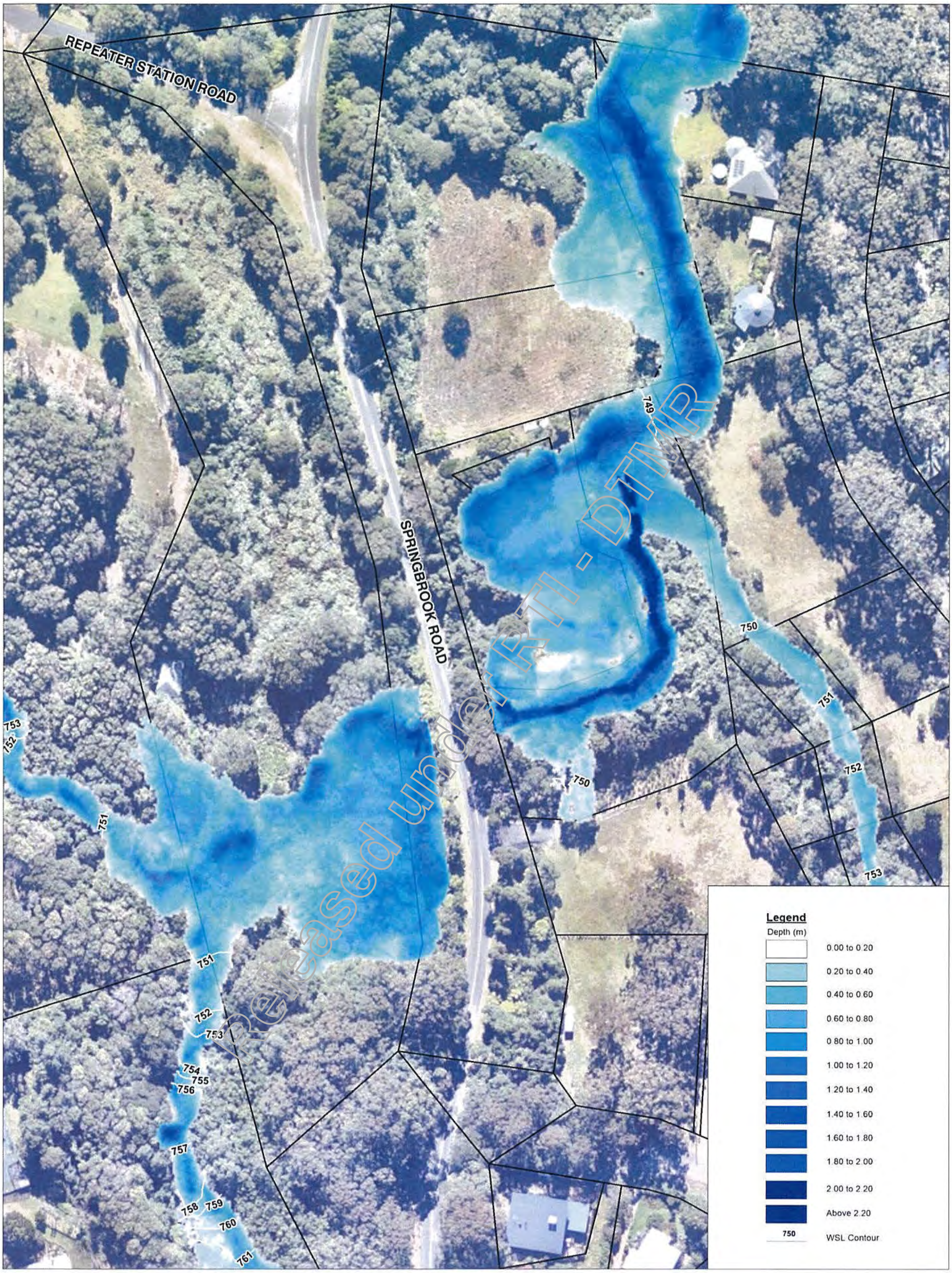
06_LilNerang_Afflux_D04c_D04e_5%_001

07_LilNerang_Afflux_D04f_D04e_1%_001

08_LilNerang_Afflux_D04f_D04e_2%_001

09_LilNerang_Afflux_D04f_D04e_5%_001

APPENDIX B PHOTOGRAPH: DOWNSTREAM HOUSE



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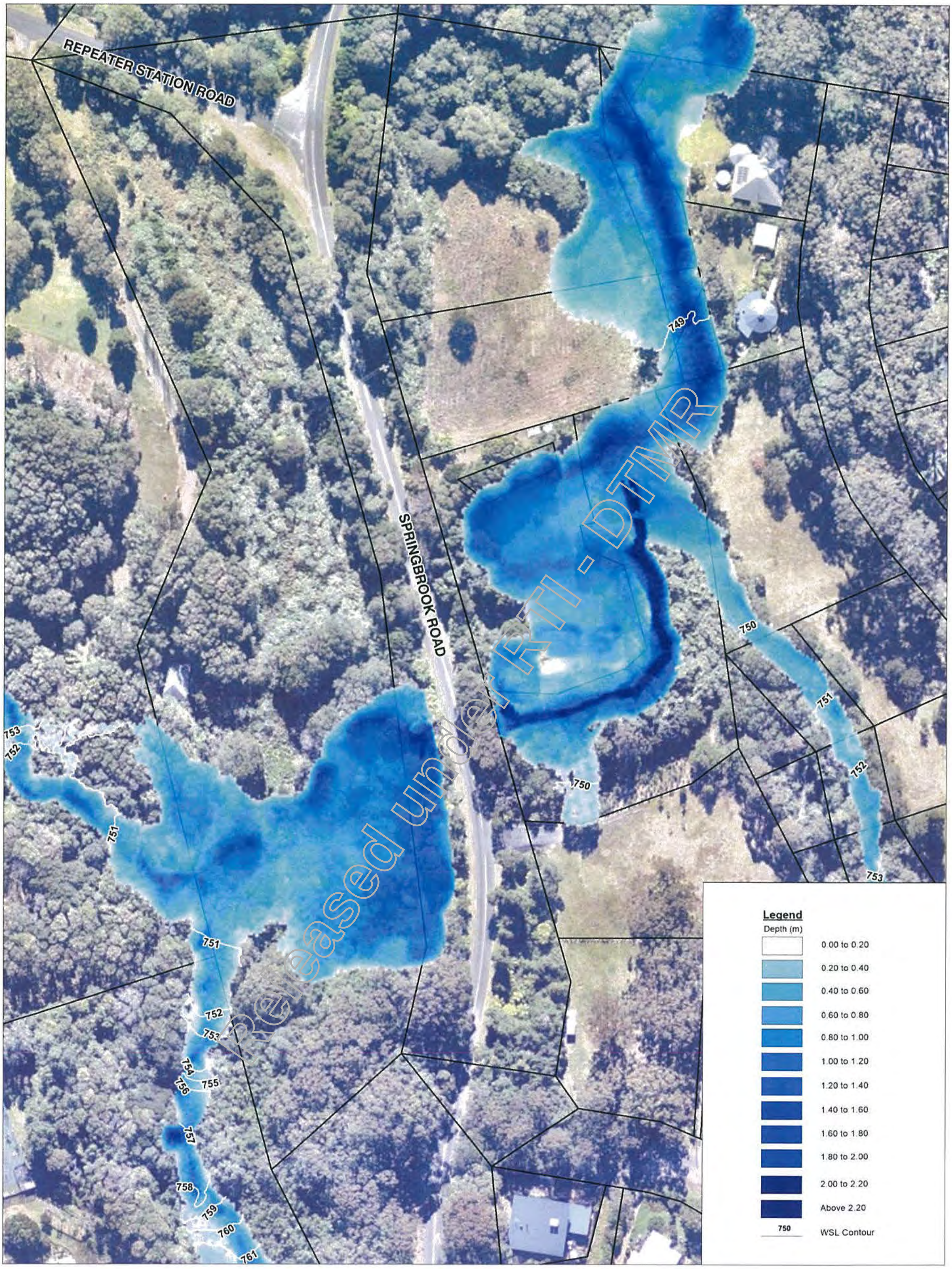
	PROJECT NO. 30032217 PROJECT TITLE LITTLE NERANG CREEK CULVERT REMEDIATION		CONSULTANT SMEC SMEC Australia Ltd Level 1, 154 Melbourne Street South Brisbane QLD 4101
	TITLE **FLOOD DEPTH MAP - 18% AEP D04 (4/1200mm RCP)**		



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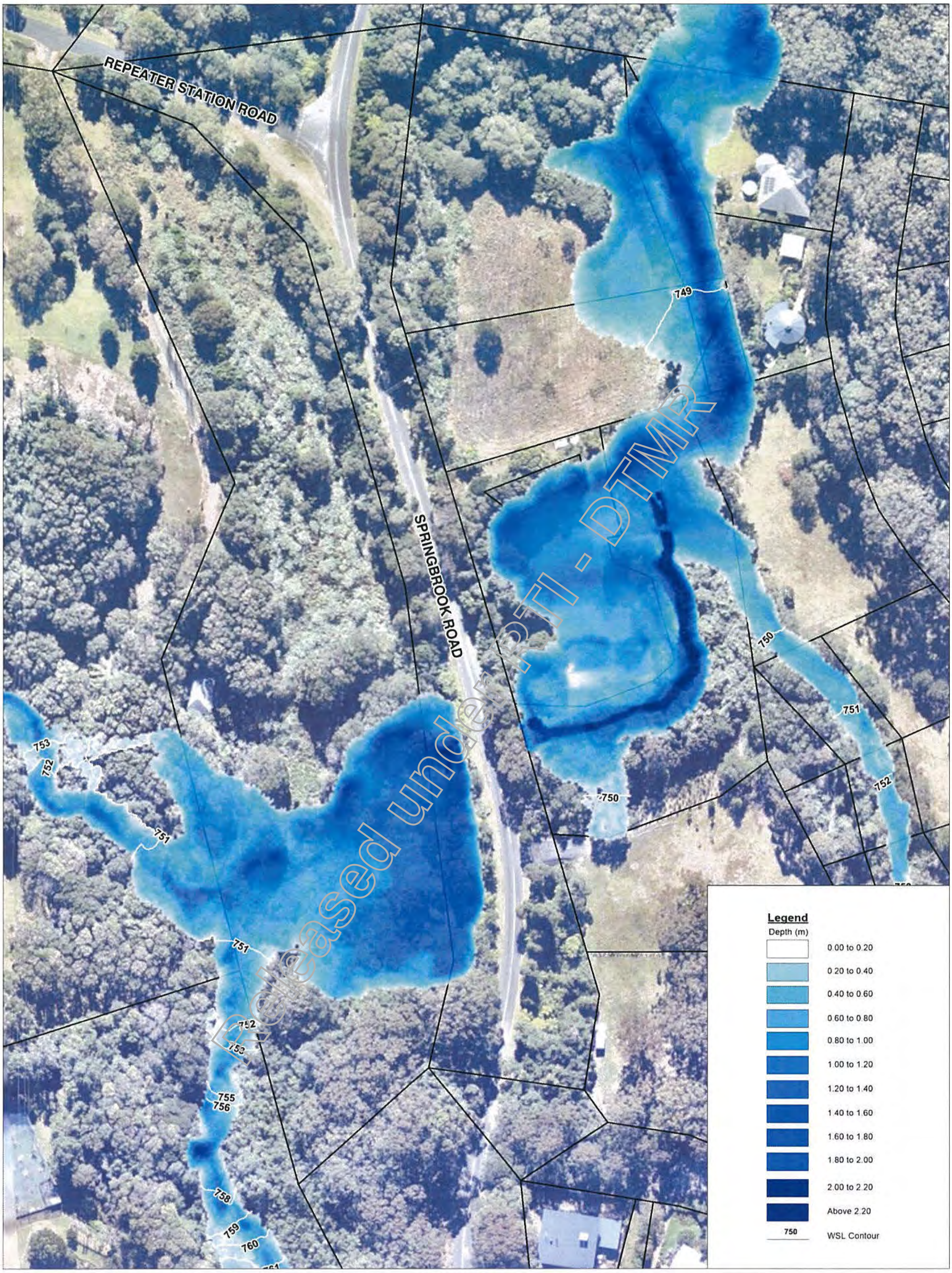

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DATE 04/09/2018

PROJECT NO. 30032217

PROJECT TITLE LITTLE NERANG CREEK CULVERT REMEDIATION

TITLE **FLOOD DEPTH MAP - 2% AEP D04 (4/1200mm RCP)**

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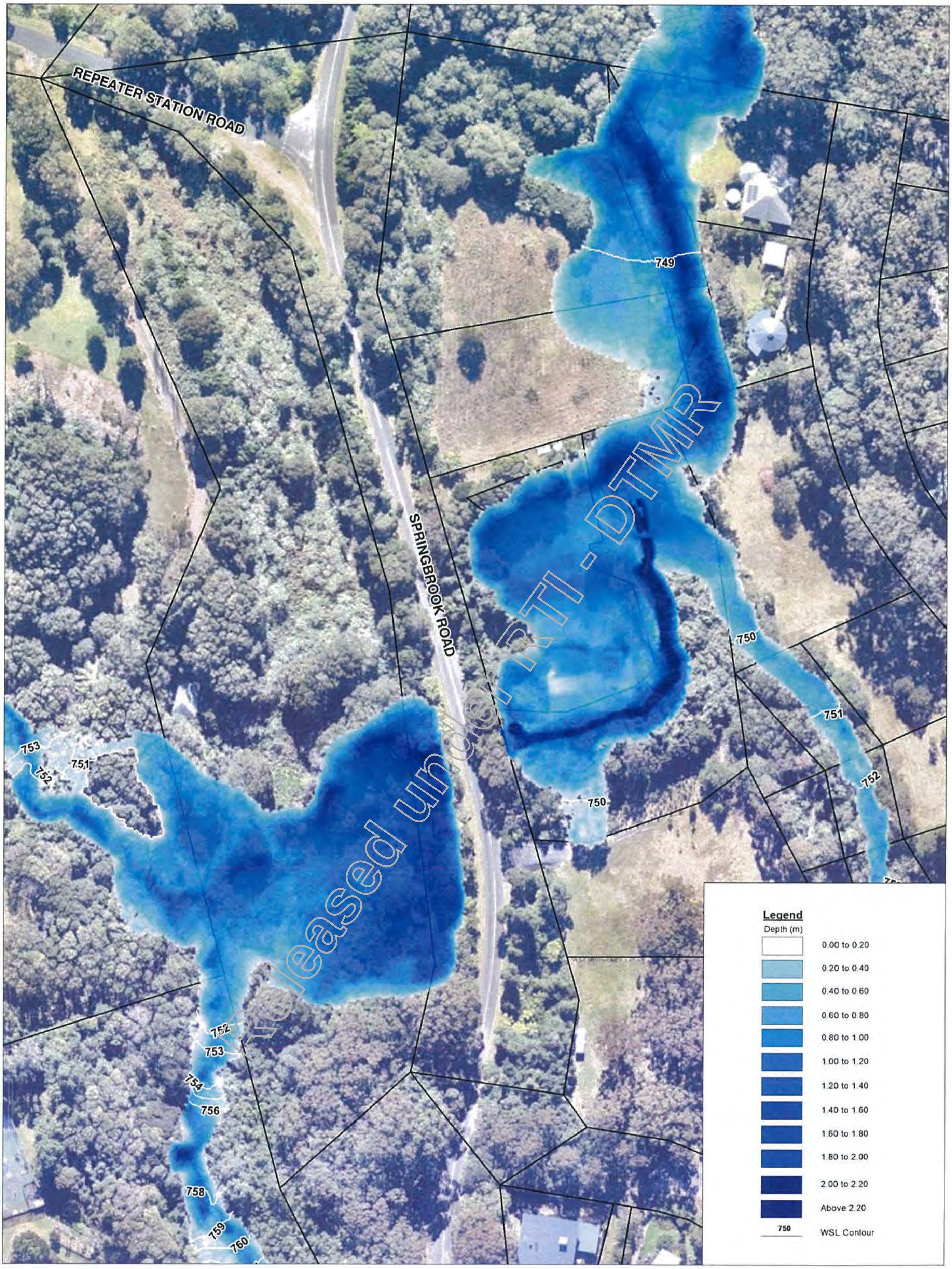

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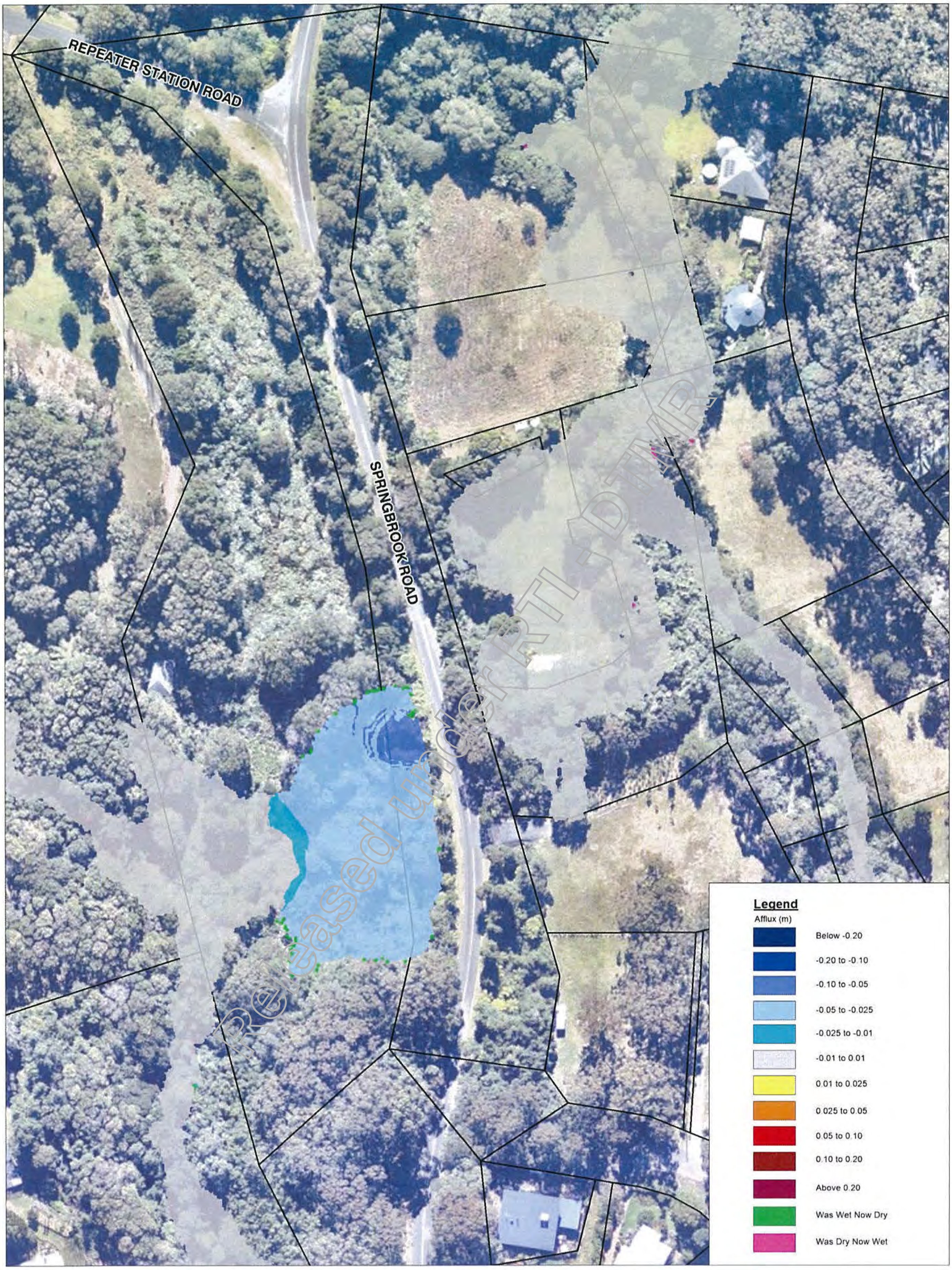

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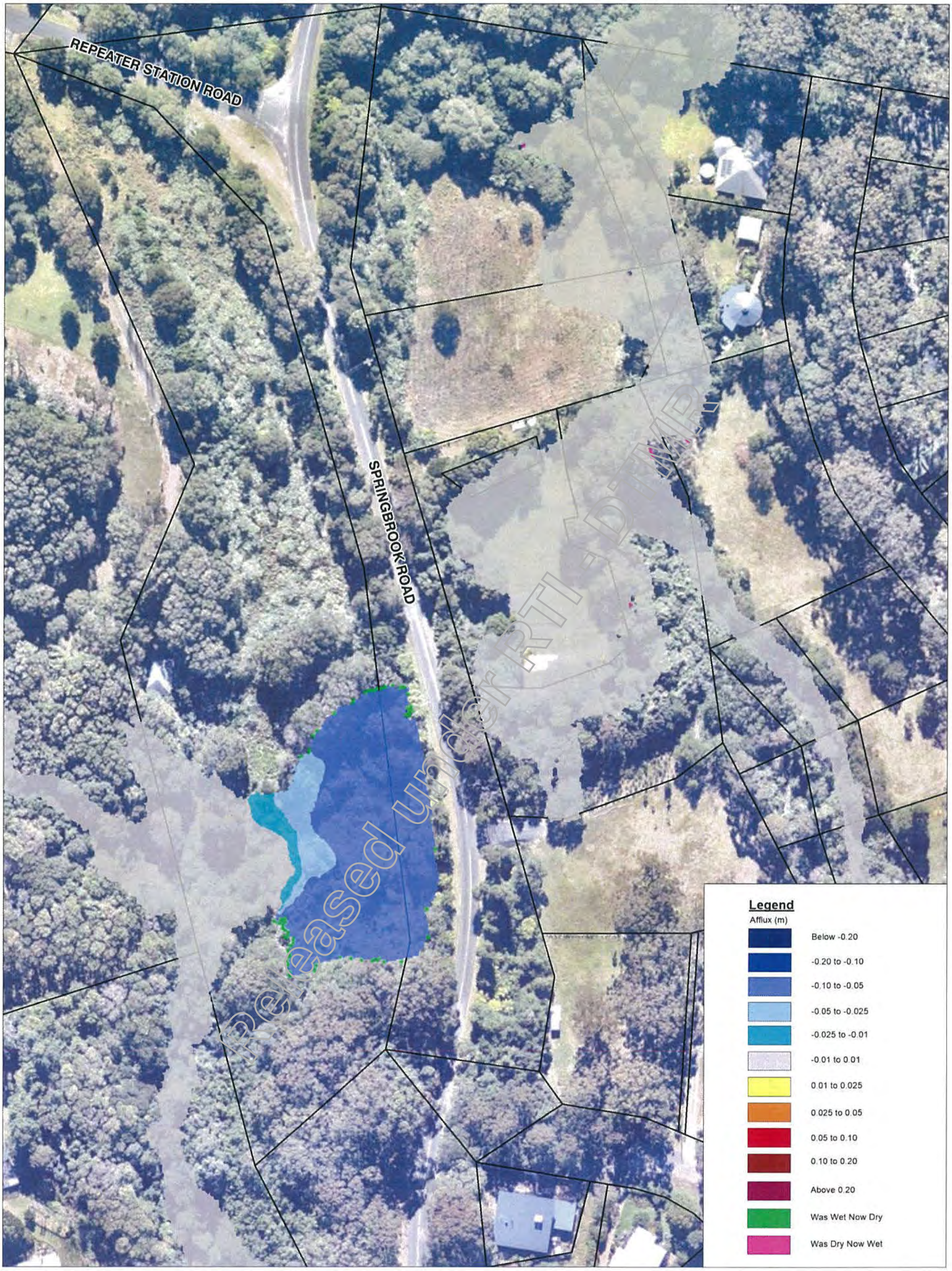

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CREATED BY not relevant
DATE 04/09/2018
PROJECT NO. 30032217
PROJECT TITLE LITTLE NERANG CREEK CULVERT REMEDIATION
TITLE **FLOOD AFFLUX MAP - 18% AEP D04b (4/1500mm RCP) vs. D04 (4/1200mm RCP)**

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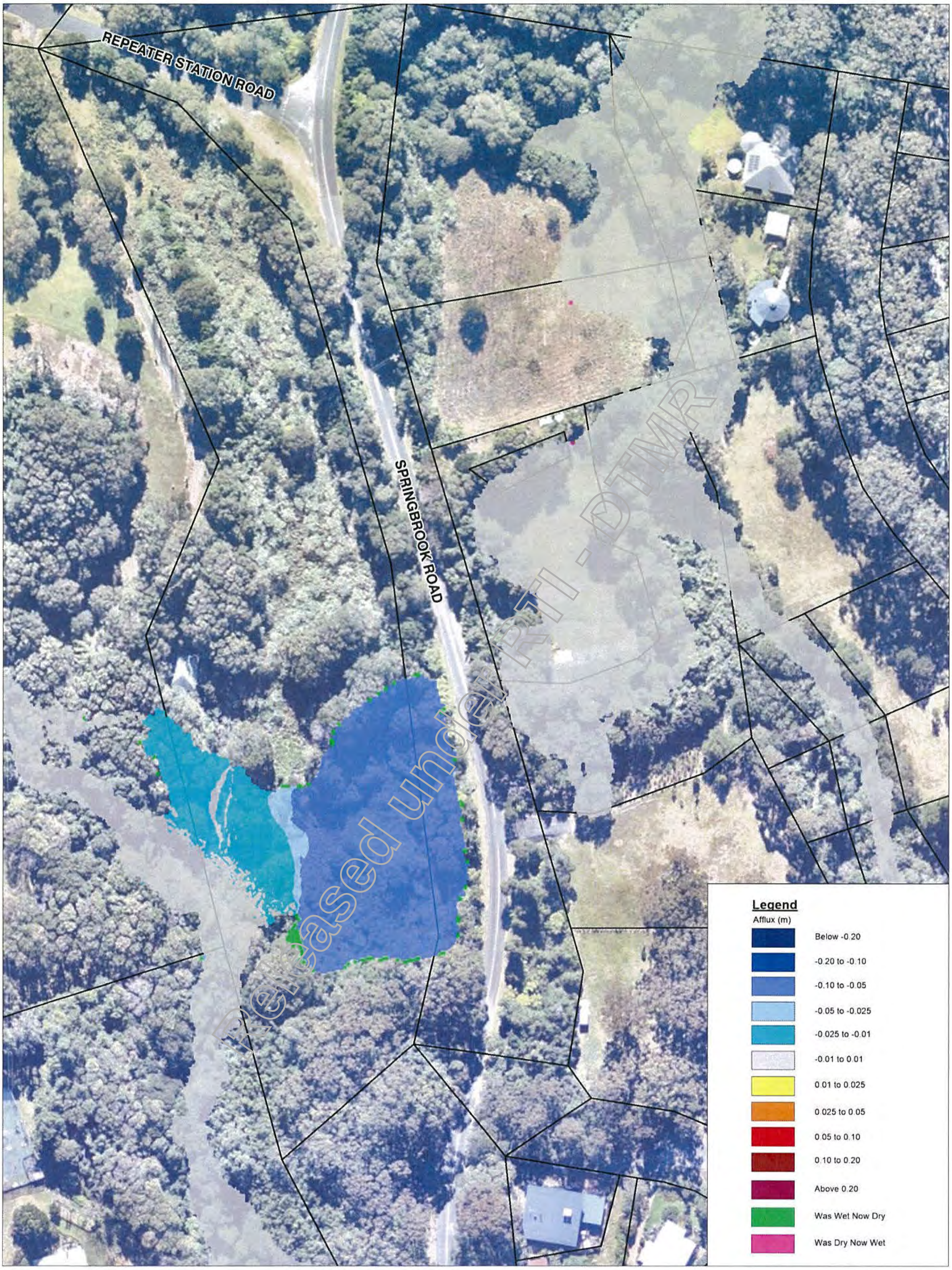

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REVISION A

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DATE 04/09/2018

PROJECT NO. 30032217

PROJECT TITLE LITTLE NERANG CREEK CULVERT REMEDIATION

TITLE **FLOOD AFFLUX MAP - 5% AEP D04a (4/1350mm RCP) vs. D04 (4/1200mm RCP)**

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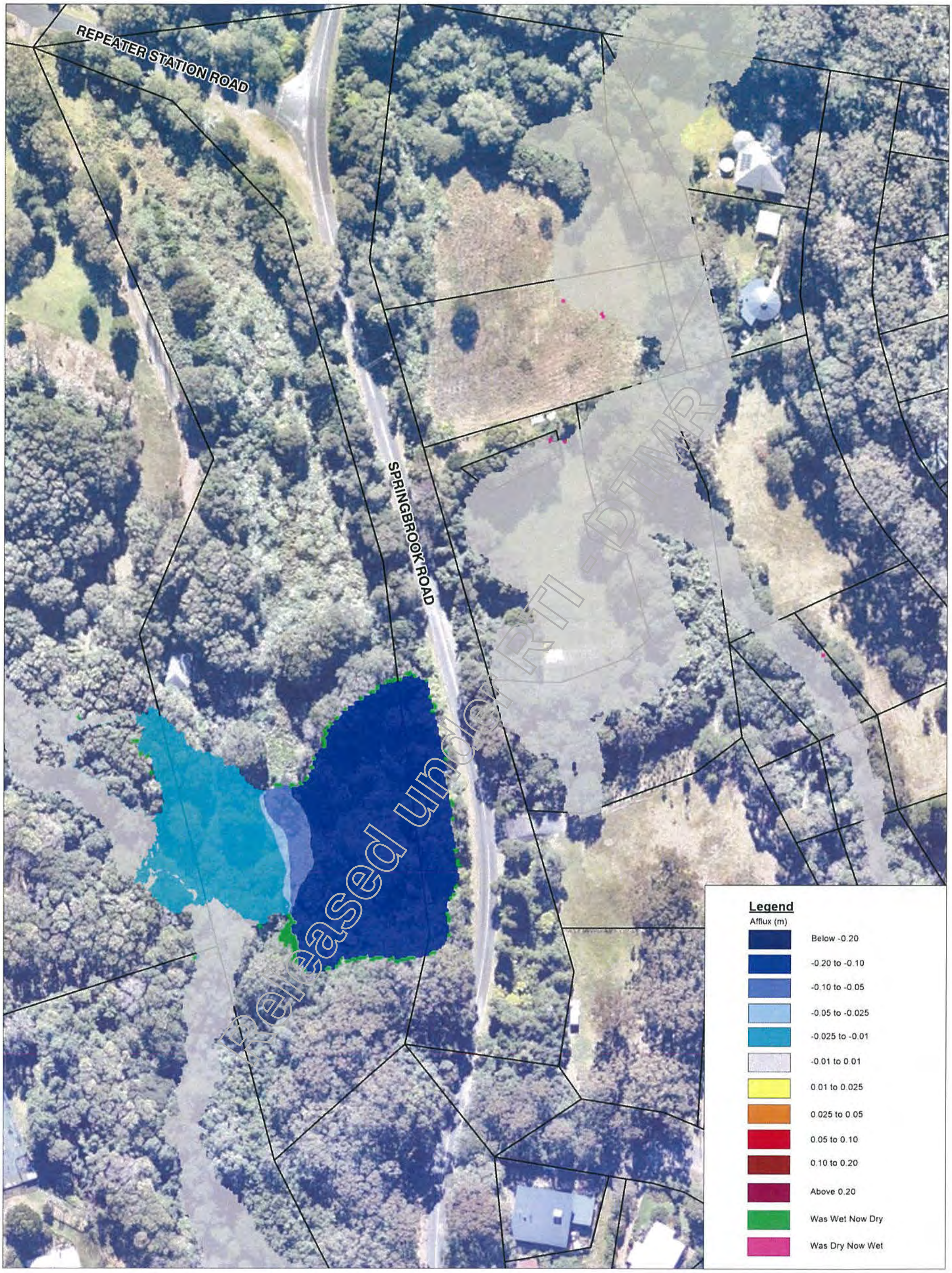

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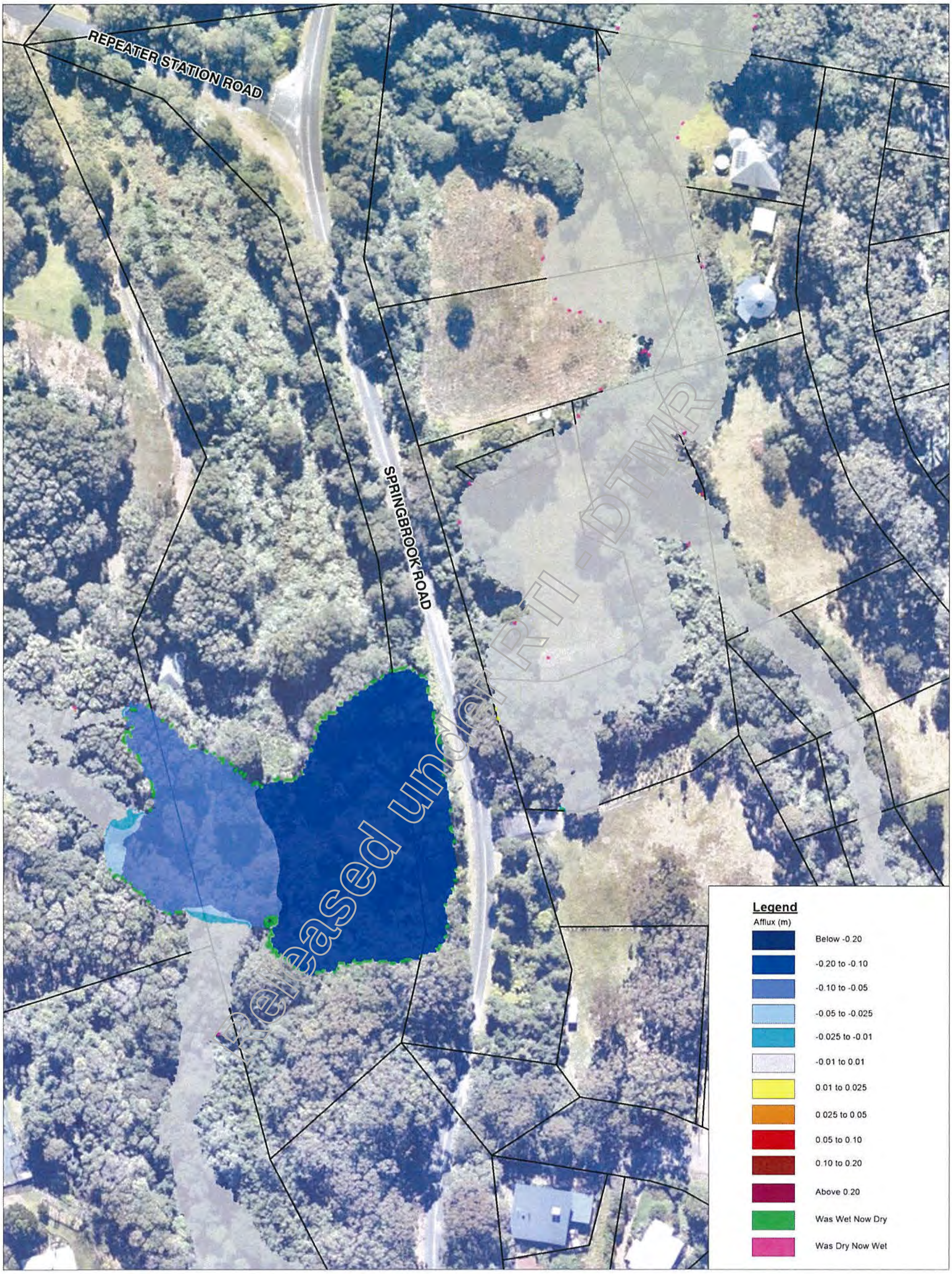
			CONSULTANT SMEC SMEC Australia Ltd Level 1, 154 Melbourne Street South Brisbane QLD 4101



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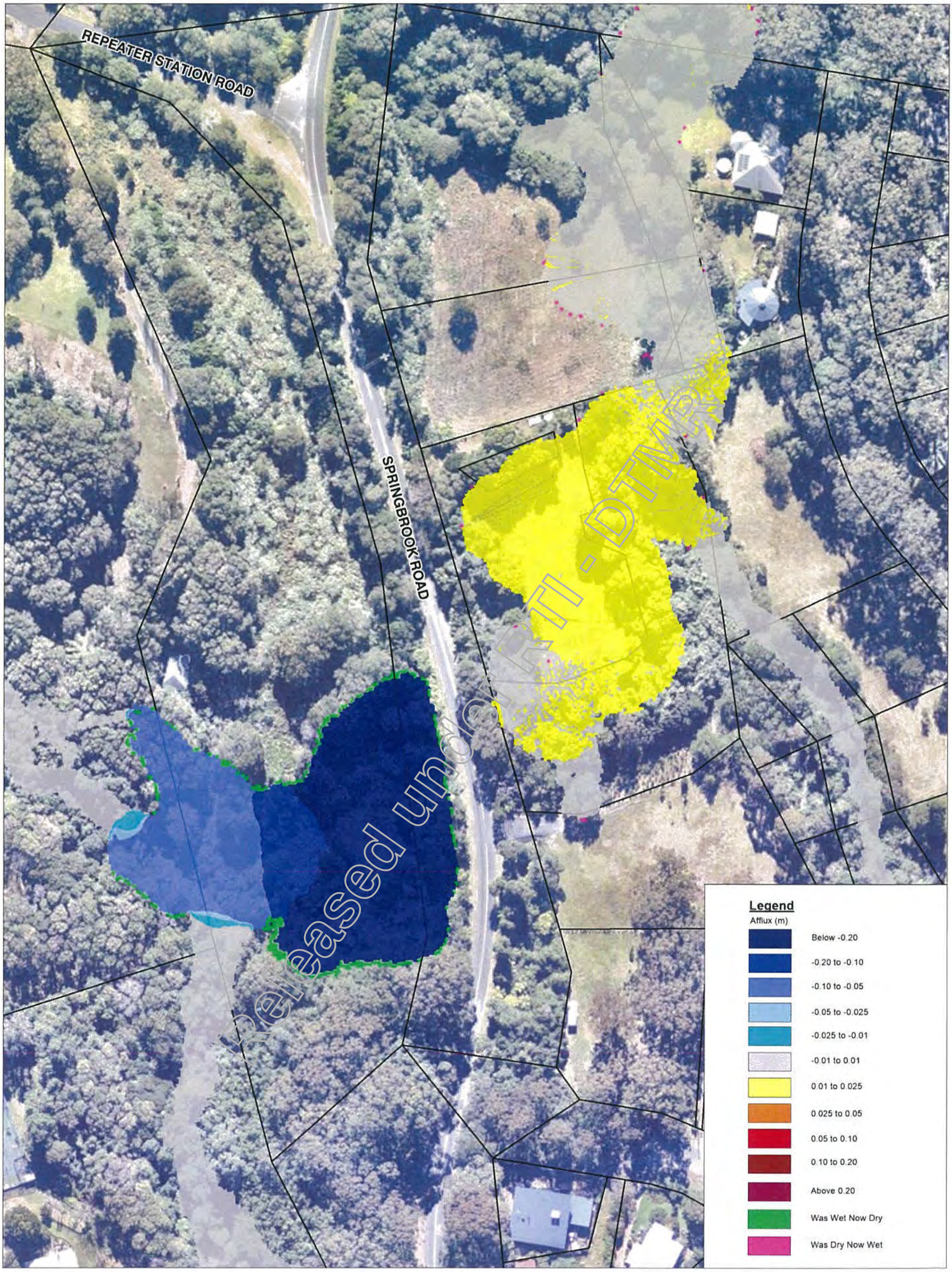

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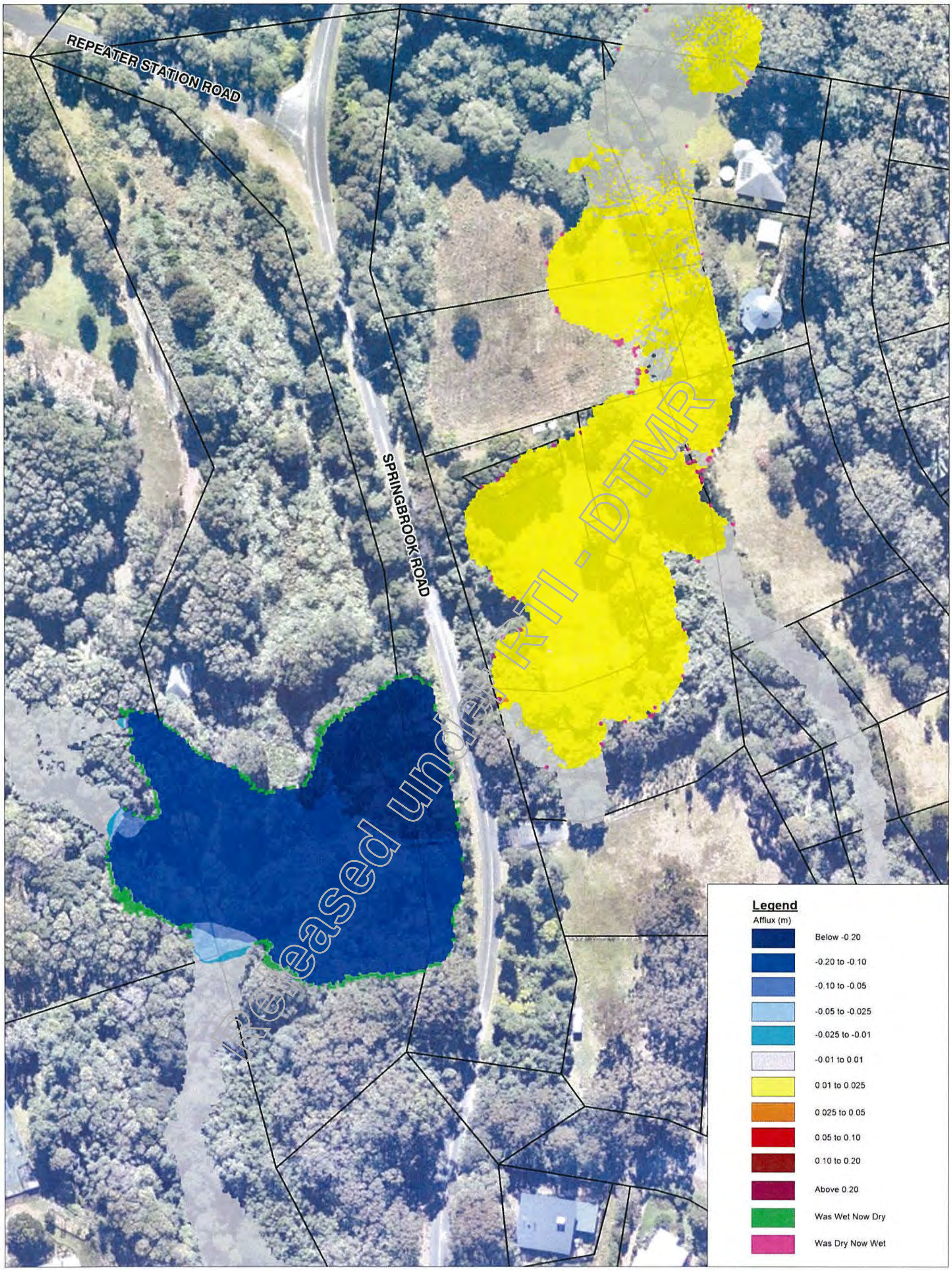

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DRAWING NO. 07_LilNerang_Afflux_D04a_D04_1%_001
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PROJECT NO. 30032217 PROJECT TITLE LITTLE NERANG CREEK CULVERT REMEDIATION
TITLE **FLOOD AFFLUX MAP - 1% AEP D04a (4/1350mm RCP) vs. D04 (4/1200mm RCP)**

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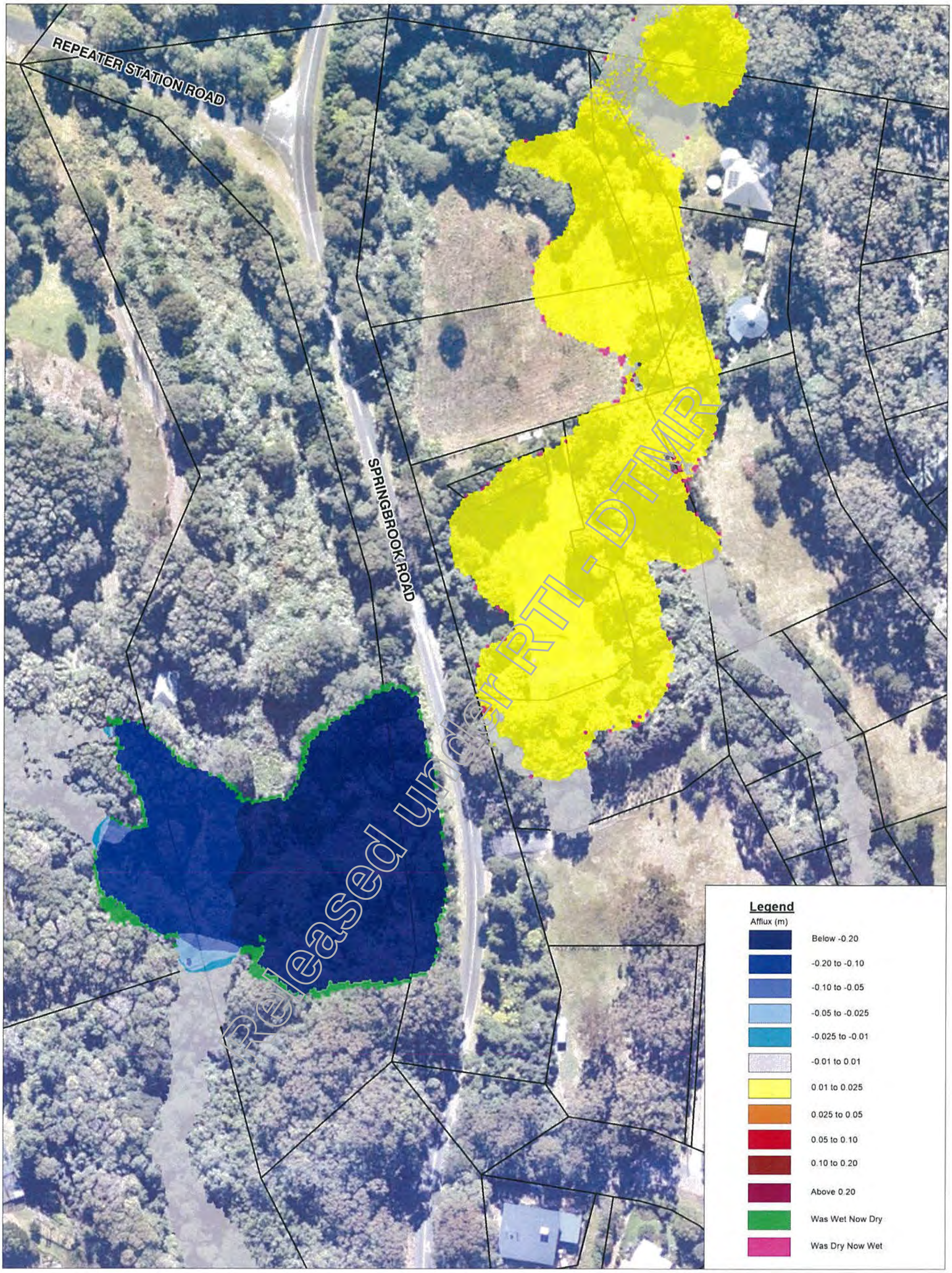

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DATE 04/09/2018
STATUS ISSUE
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PROJECT TITLE LITTLE NERANG CREEK CULVERT REMEDIATION
TITLE **FLOOD AFFLUX MAP - 1% AEP D04b (4/1500mm RCP) vs. D04 (4/1200mm RCP)**

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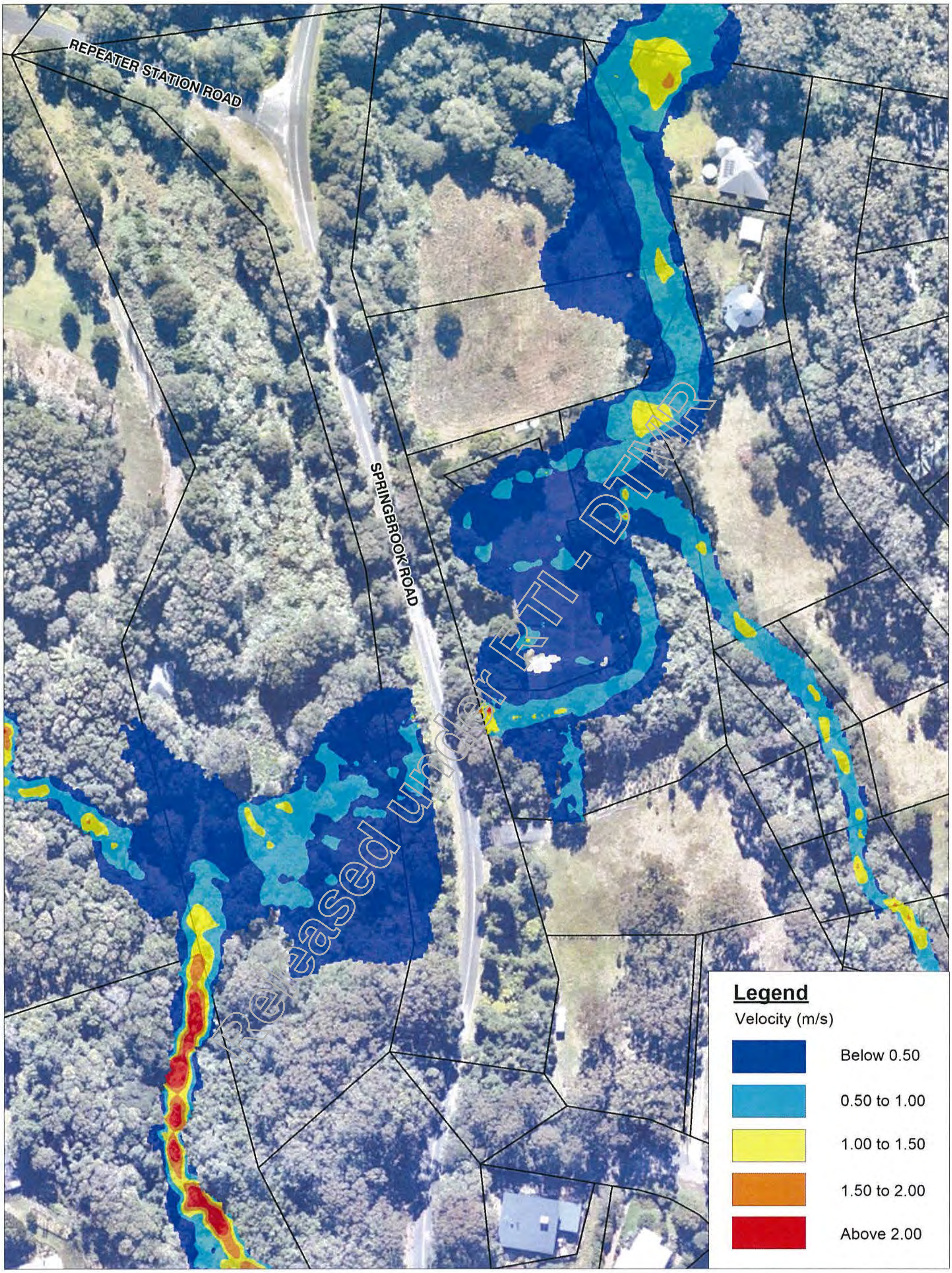

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	TITLE **FLOOD VELOCITY MAP - 18% AEP D04 (4/1200mm RCP)**		

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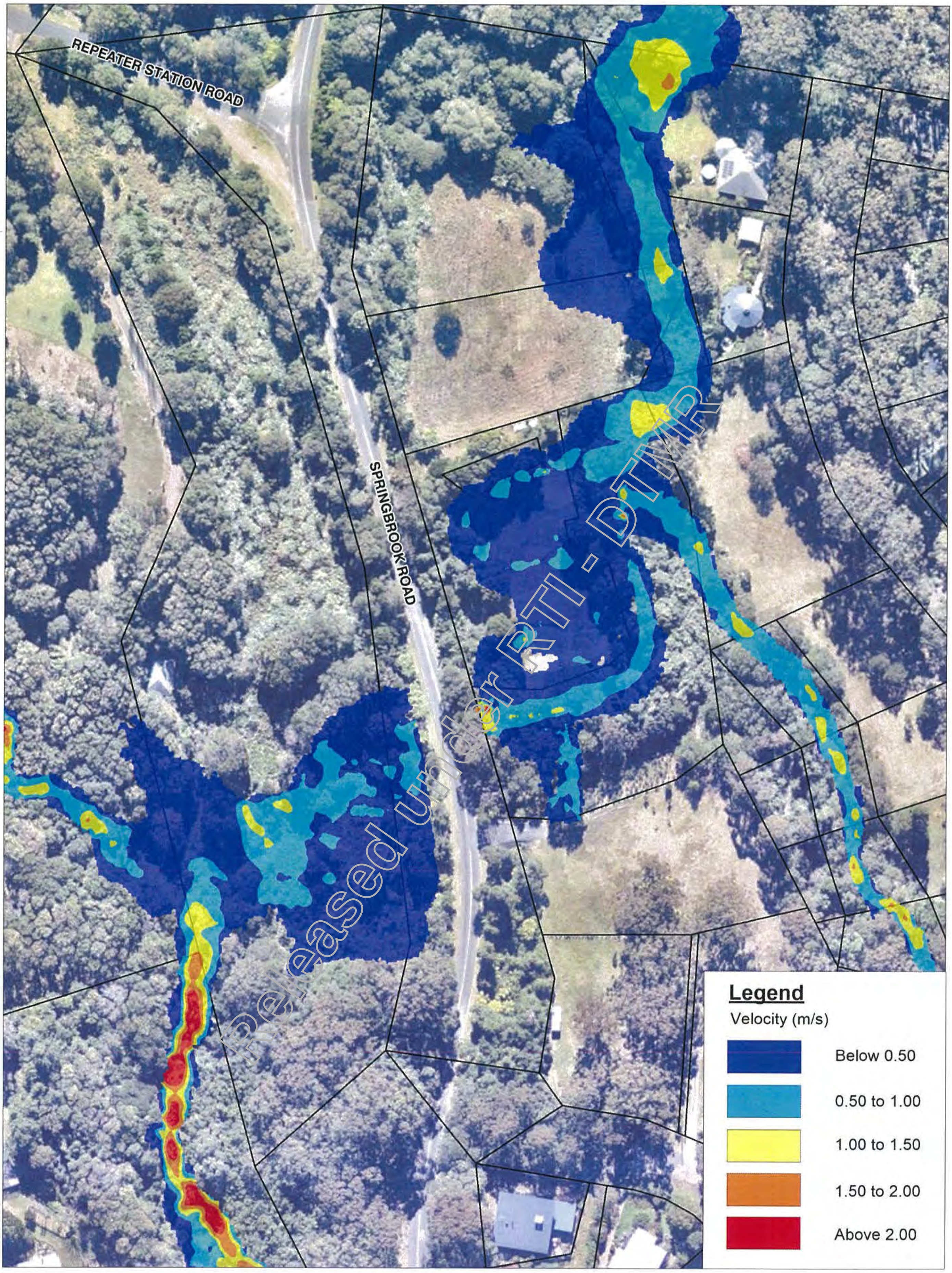

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DATE 04/09/2018

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TITLE **FLOOD VELOCITY MAP - 18% AEP D04a (4/1350mm RCP)**

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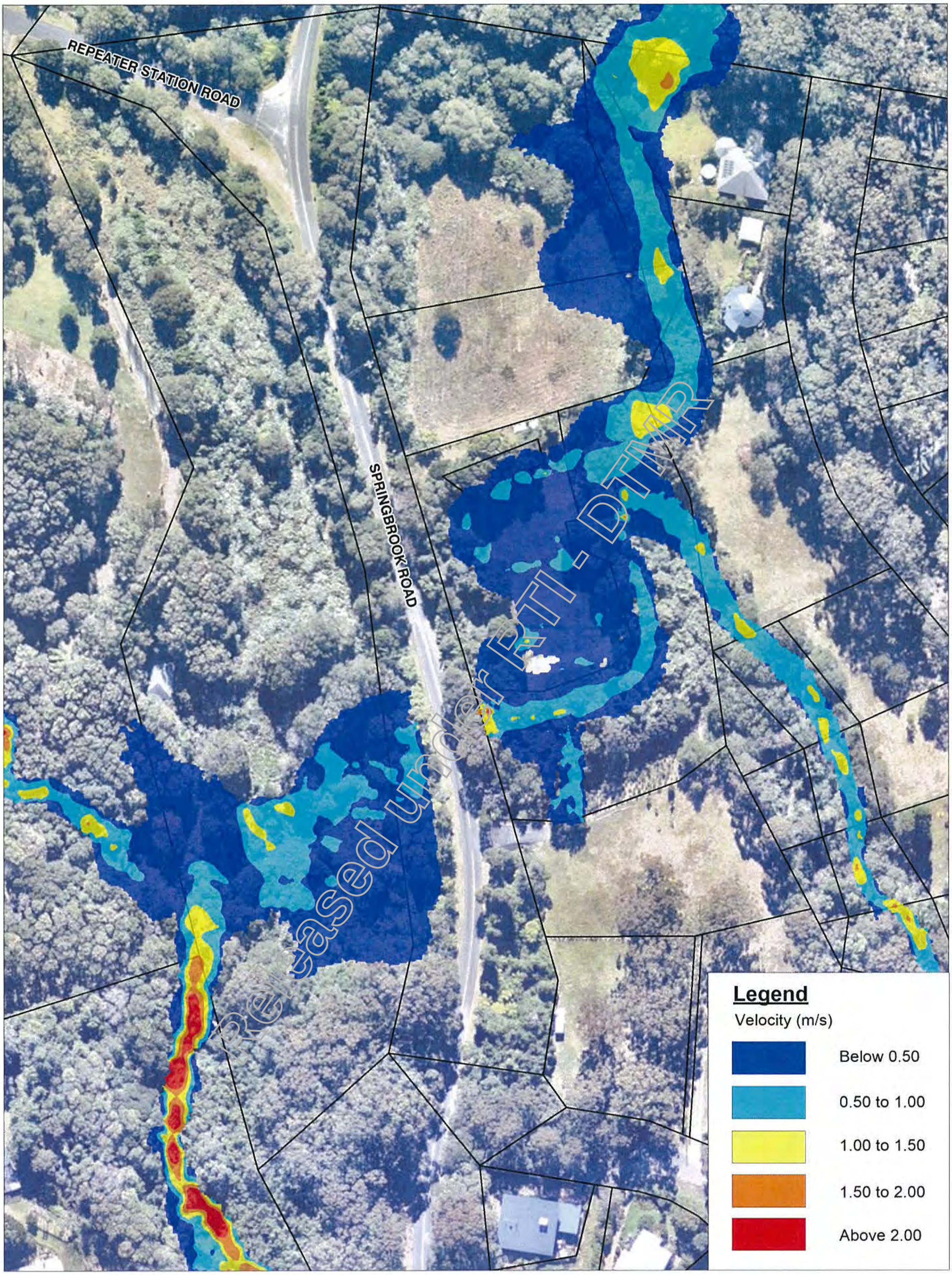

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PROJECT NO. 30032217
PROJECT TITLE LITTLE NERANG CREEK CULVERT REMEDIATION
TITLE **FLOOD VELOCITY MAP - 18% AEP D04b (4/1500mm RCP)**

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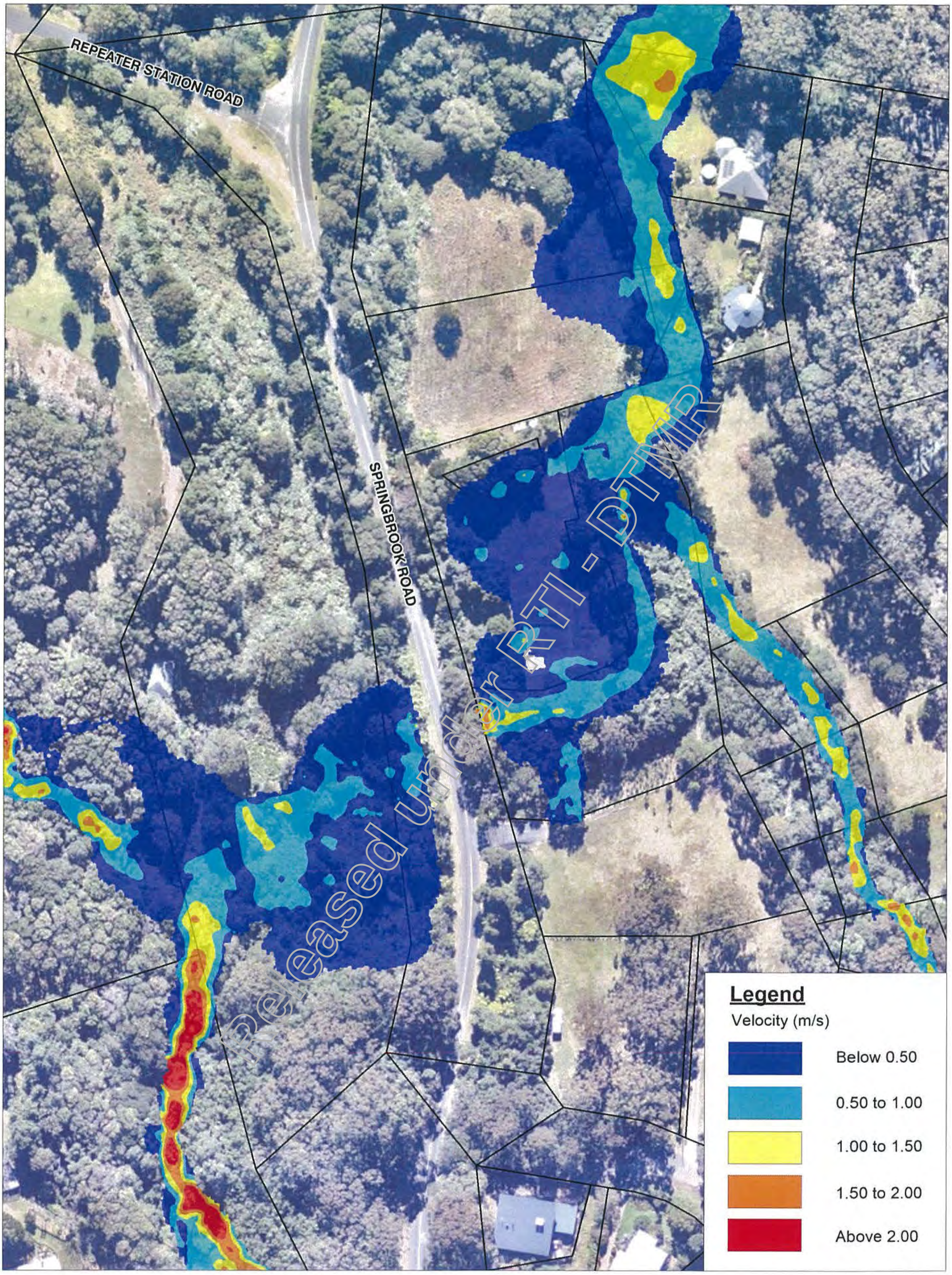

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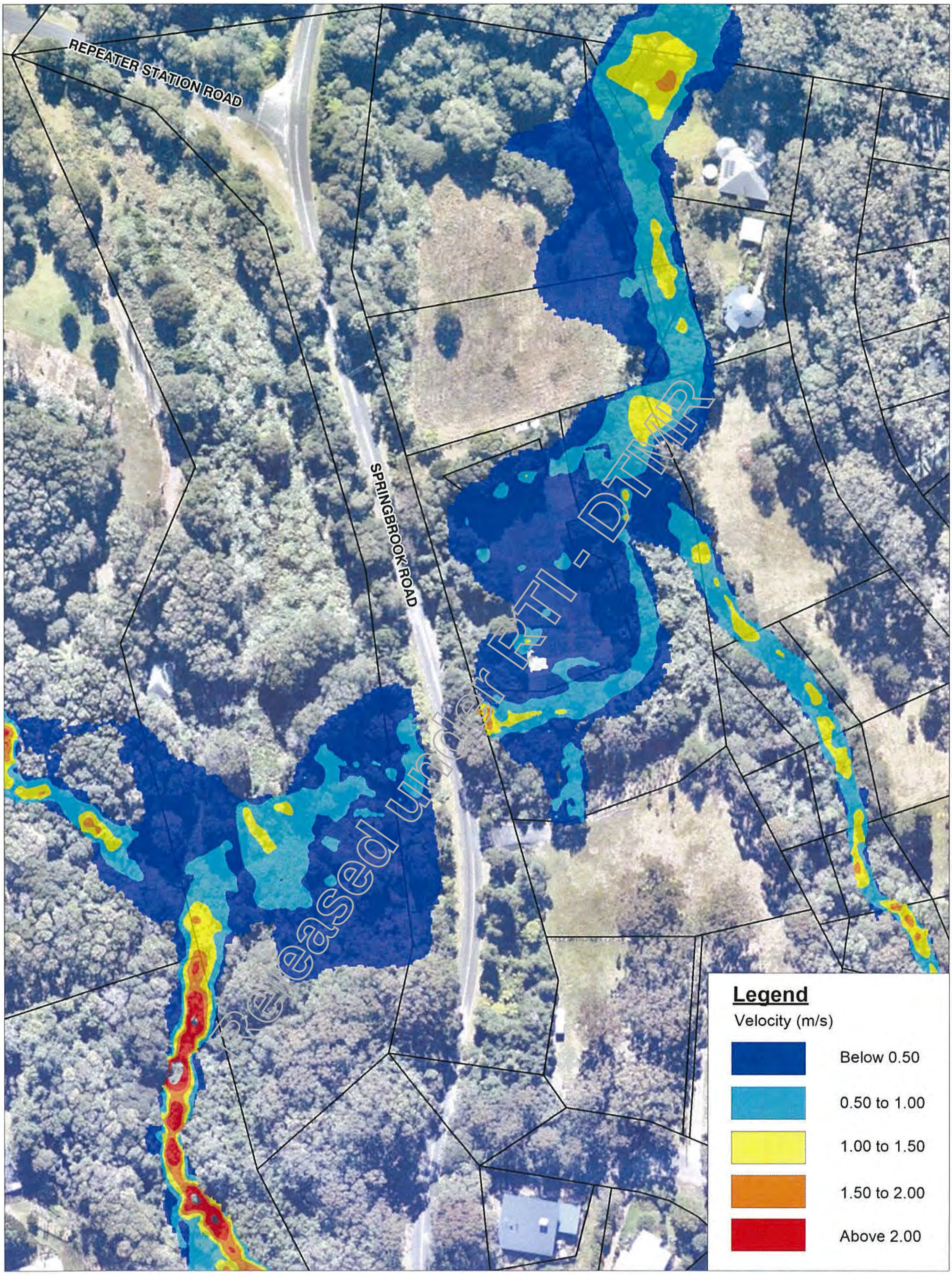

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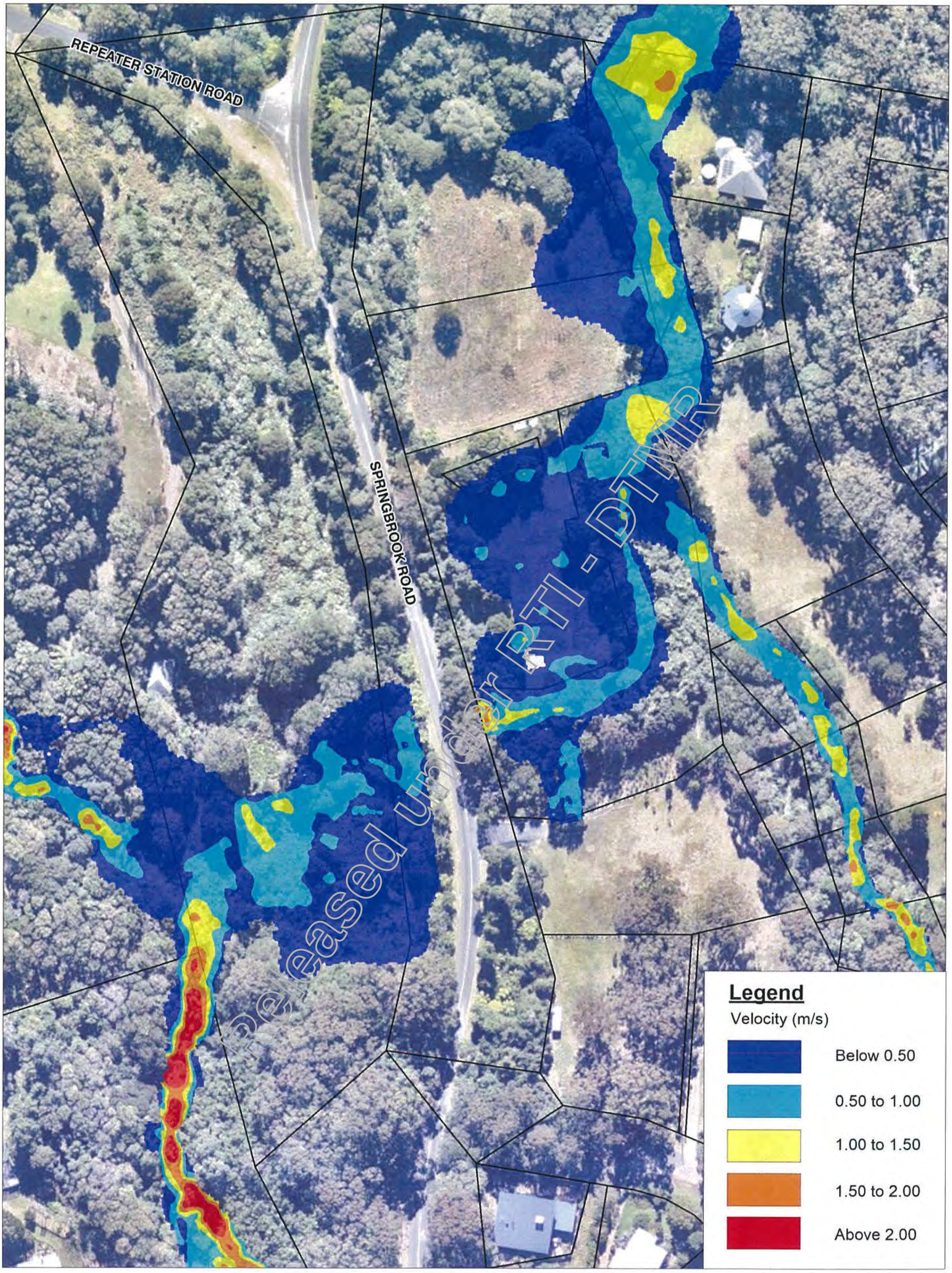

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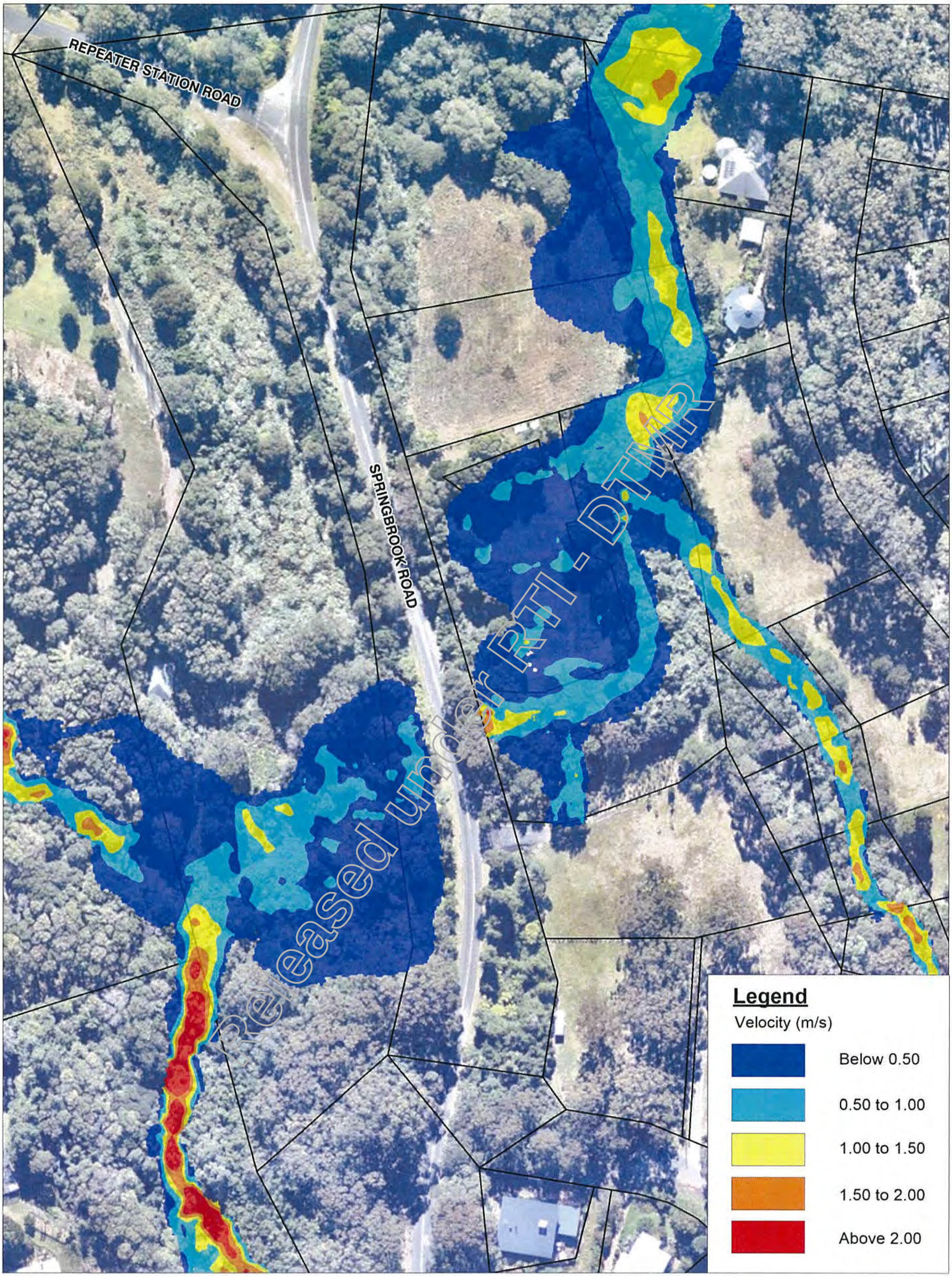

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REVISION A
PROJECT NO. 30032217
PROJECT TITLE LITTLE NERANG CREEK CULVERT REMEDIATION
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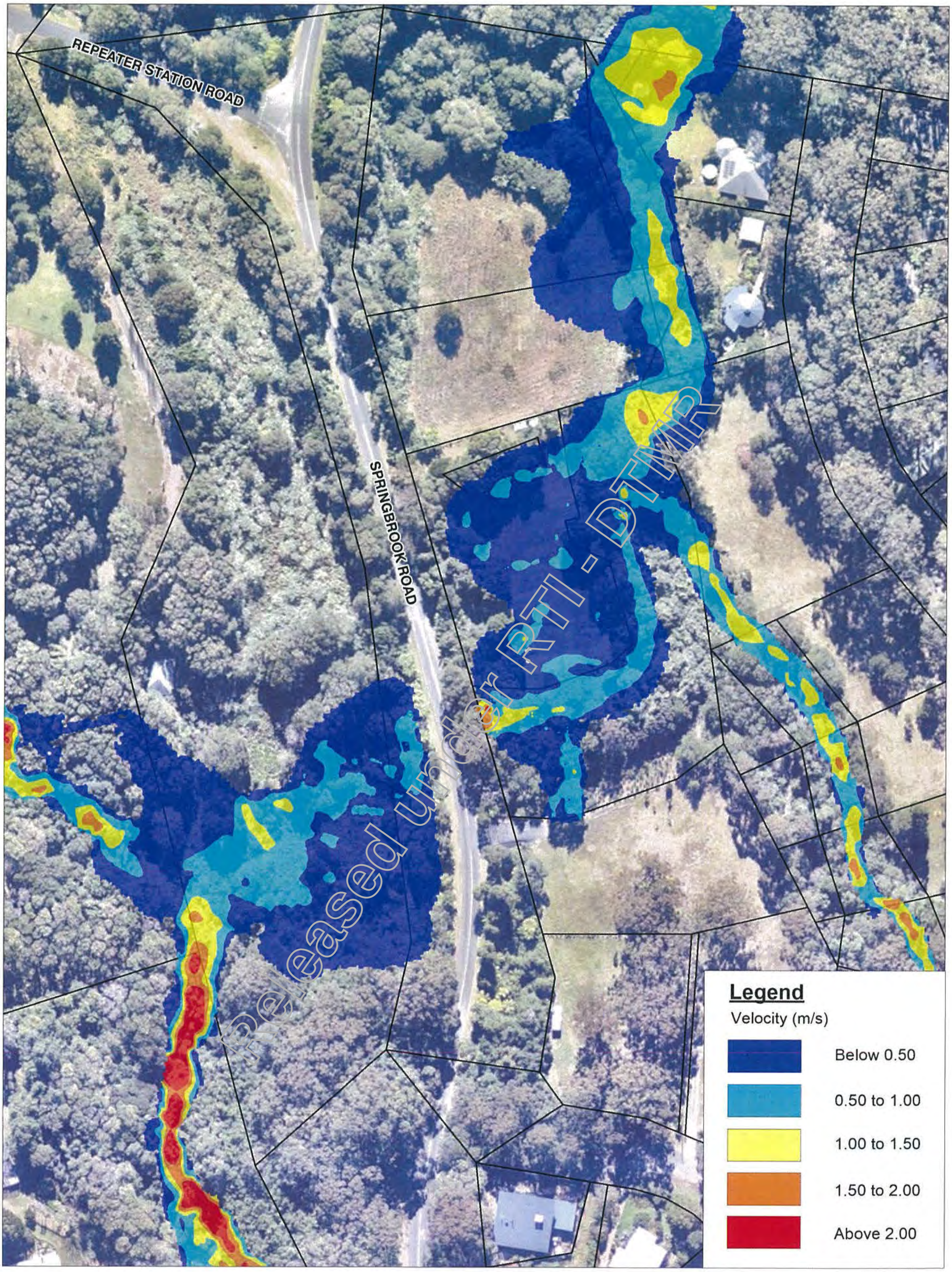

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DRAWING NO. 08_LilNerang_Velocity_D04a_2%_001

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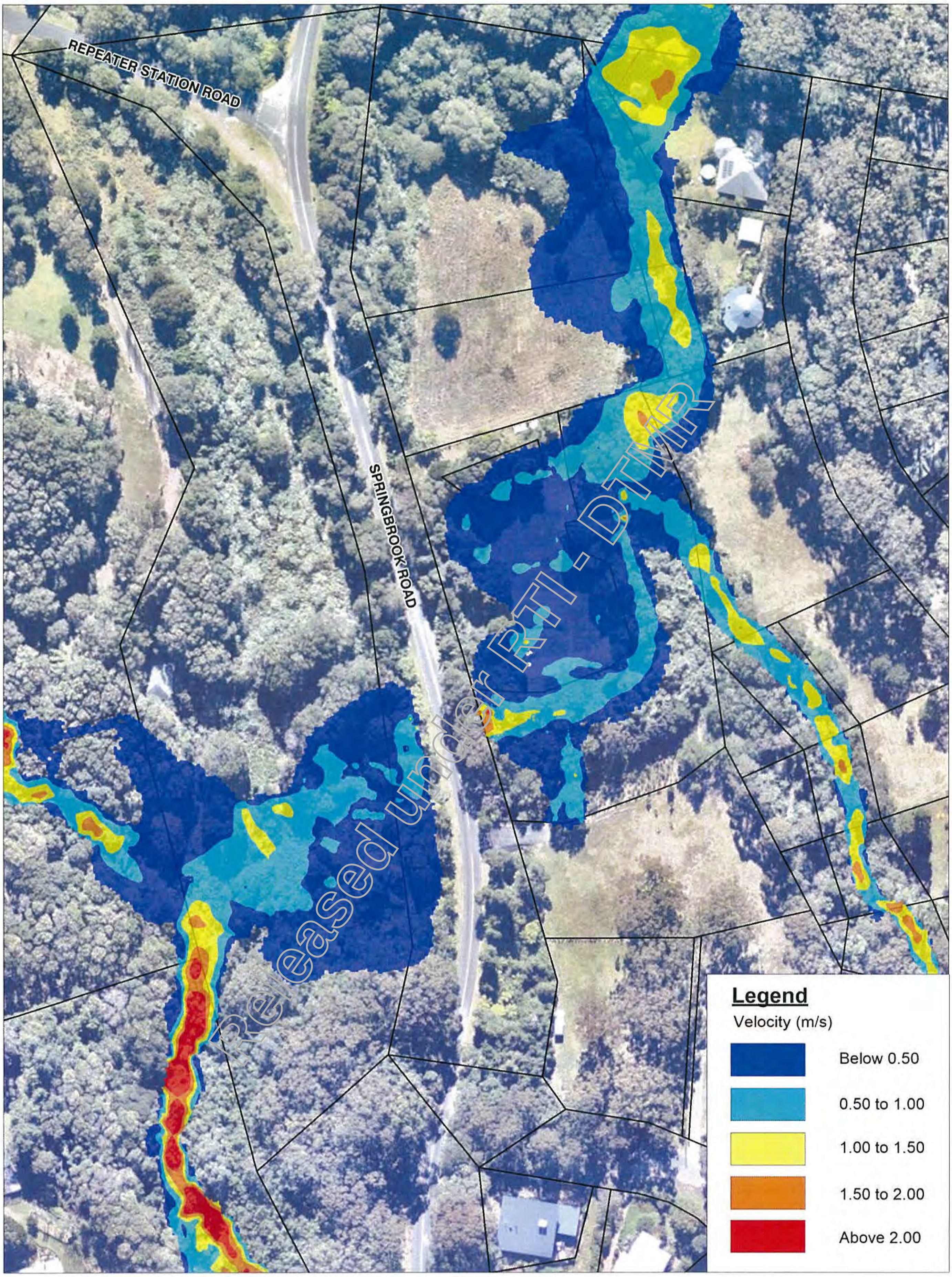

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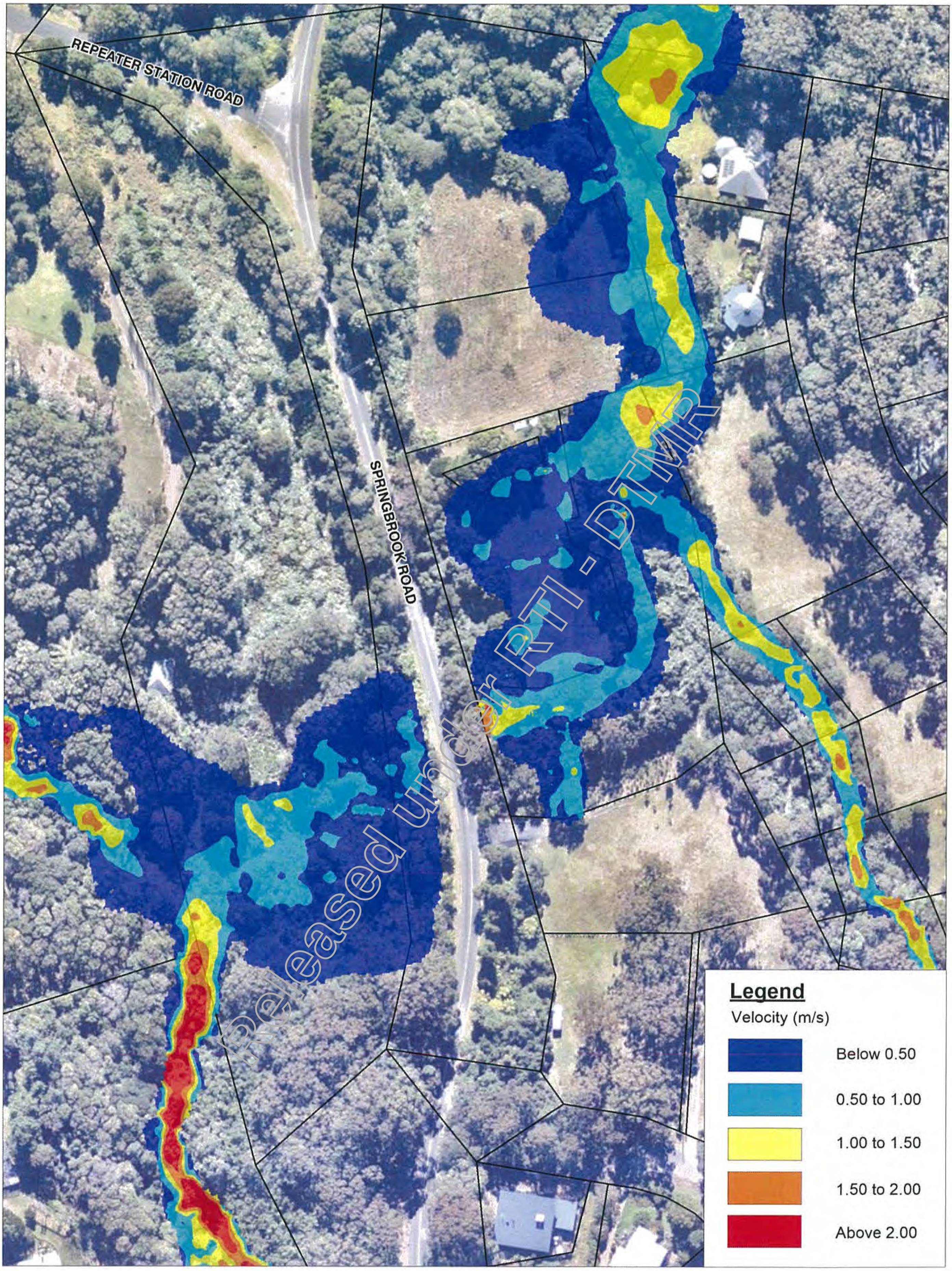

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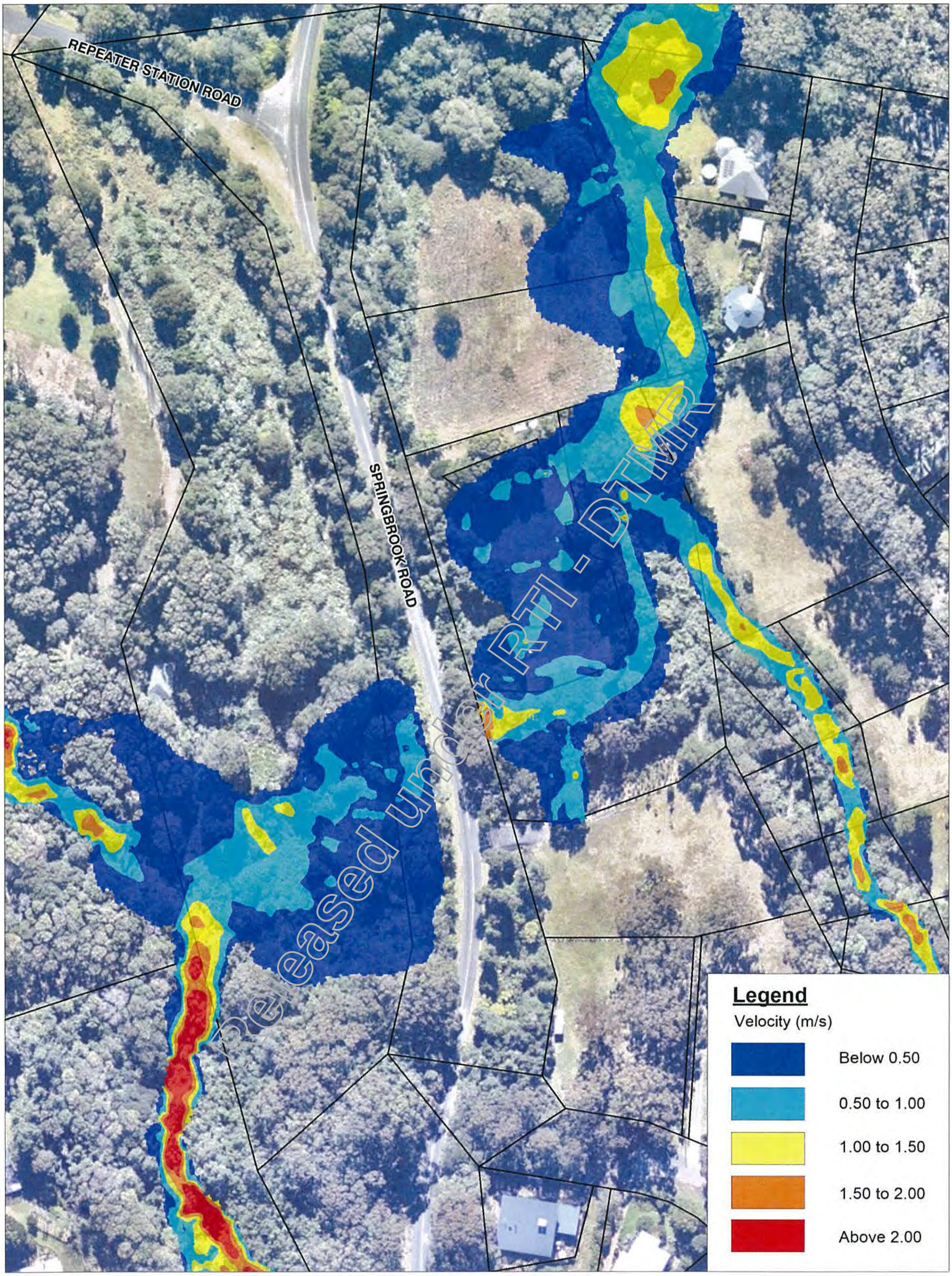

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PROJECT NO. 30032217
PROJECT TITLE LITTLE NERANG CREEK CULVERT REMEDIATION
TITLE **FLOOD VELOCITY MAP - 1% AEP D04a (4/1350mm RCP)**

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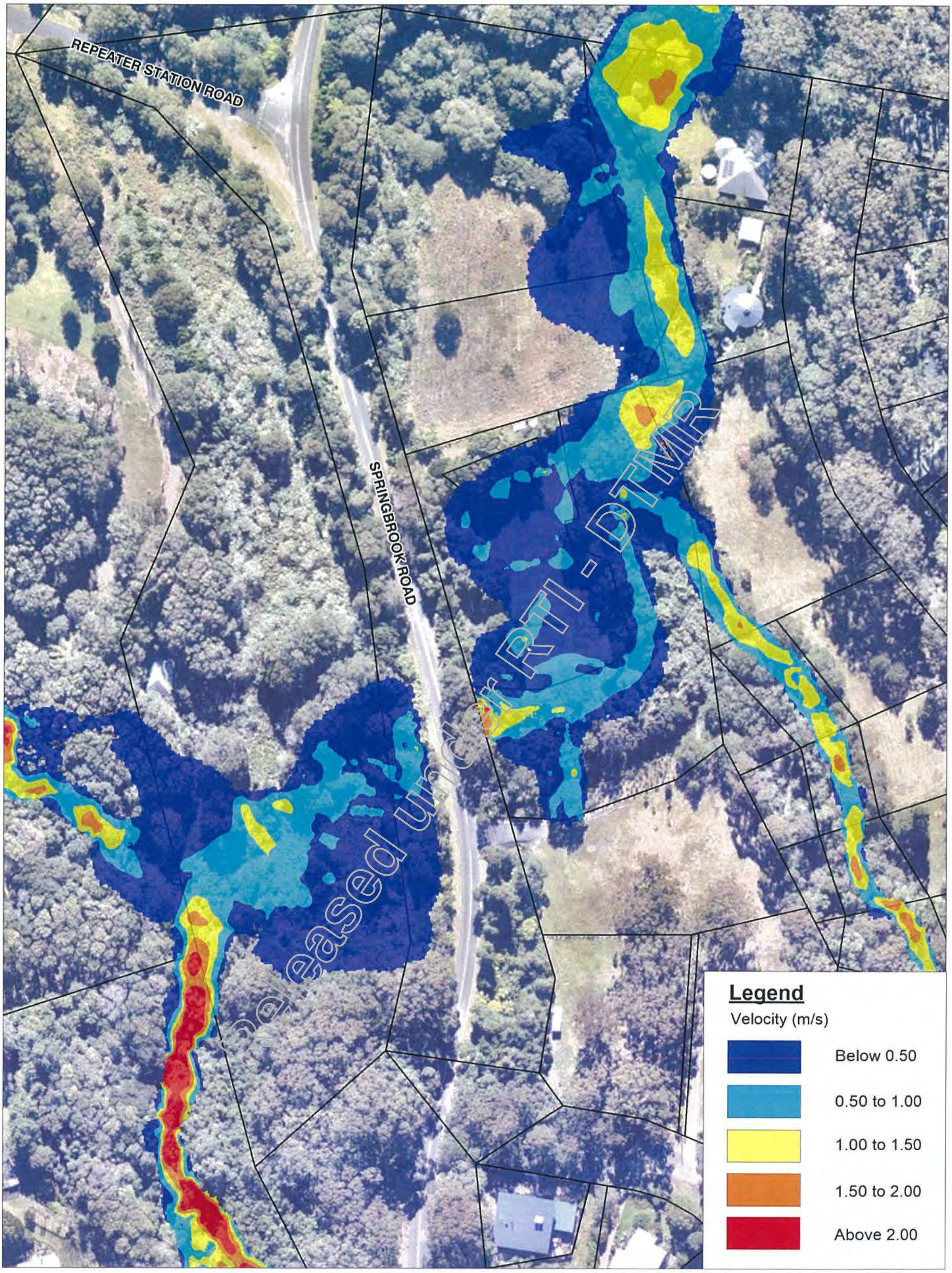

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